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**NEW
LOOK**

Sky at Night

#165 FEBRUARY 2019

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AT ITS MOST DRAMATIC MOMENT

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Welcome

Get ready for moonrise this month – it's going to be super!

I'm delighted to be greeting you at the start of our first new-look issue. This month you'll notice new headlines and sections, like 'Inside The Sky at Night' on page 16, and you'll also see that 'The Sky Guide' at the centre of the magazine is now in its own booklet, which you can pull out and refer to separately from the main magazine. Throughout the revamp process our intention has been to give more emphasis to the stunning images we love to feature.

Talking of which, this month is a perfect time to capture one of the most photogenic targets in the night sky: the rising full Moon low to the horizon. On 19 February we'll be treated to the largest perigee full Moon of 2019. On page 35, expert astrophotographer Will Gater takes you through the equipment and techniques you need to get the perfect shot, with the lunar disc looming larger than life over the Earthly foreground.

To discover more stunning sights like this, sign up to our new observing programme, Back Garden Astronomy Week. From 2–10 February you'll receive daily emails telling you what to see and where to look to discover some of the best views in the cosmos.

Turn to page 68 for more details!

Enjoy the issue,

Chris Bramley, Editor

PS Our next issue goes on sale 21 February.

This month's contributors

Jamie Carter

Amateur astronomer



Make this the year you go to a star party! Jamie tells us all about the astronomy get-togethers on page 28

Pete Lawrence

Astrophotographer



Pete explains how to help space science and take your deep-sky images to the next level on page 69

Laura Nuttall

Astrophysicist



Laura discusses the treat that is Stephen Hawking's last book, asking all the big questions, on page 95

Mark Parrish

Astronomy DIY expert



Mark shows you how to make your own illuminated pad for night-time sketching on page 82

Sky at Night – lots of ways to enjoy the night sky...



Television

Find out what *The Sky at Night* team will be exploring in this month's episode on page 17



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The *BBC Sky at Night Magazine* team and guests discuss the latest astro news



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New to astronomy?

Get started with the Explainer on page 66 and our online glossary at www.skyatnightmagazine.com/dictionary

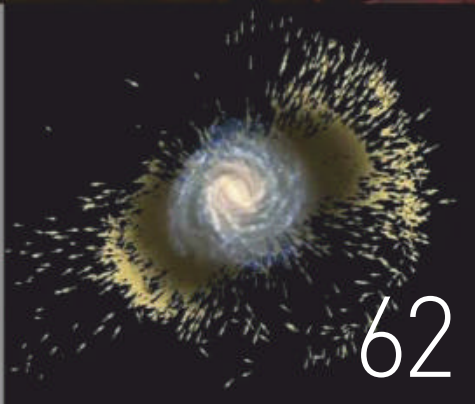
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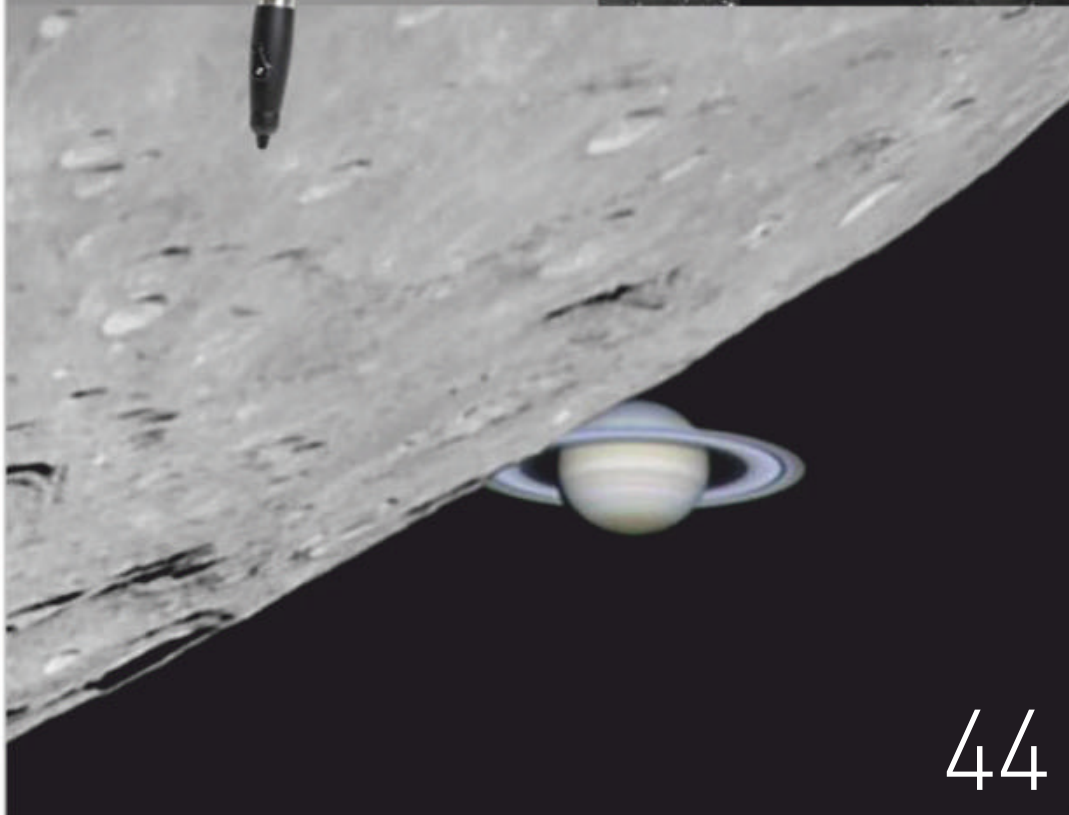
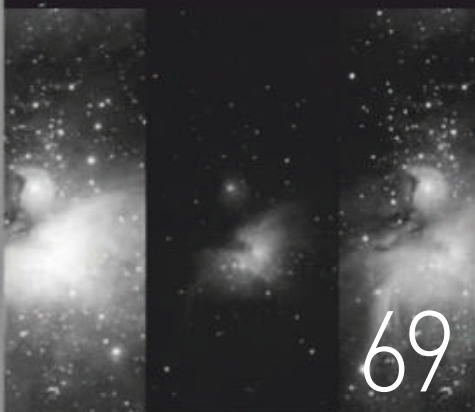
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Extra content ONLINE

Visit www.skyatnightmagazine.com/bonuscontent, select February's Bonus Content from the list and enter the authorisation code **GQQJSTK** when prompted

February highlights



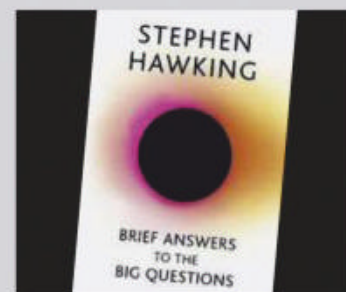
Video interview: New Horizons

On New Year's Day, NASA's New Horizons spacecraft flew by Ultima Thule, a Kuiper Belt object on the edge of the Solar System. This month we spoke to Dr Carey Lisse of the New Horizons Science Team to get the latest from the farthest flyby ever undertaken.



Watch *The Sky at Night: The Flying Telescope*

Chris Lintott boards a Boeing 747 to learn about NASA's airborne SOFIA observatory and its 2.5m reflecting telescope.

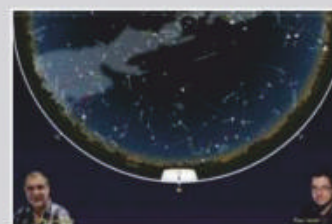


Download and listen: Hawking's final book

Brief Answers to the Big Questions is Stephen Hawking's final work. Download an excerpt from the audio book.

Hotshots gallery, extra EQMOD files, binocular tour, observing forms, deep-sky tour chart, desktop wallpapers...**and much more**

PLUS: Every month



The virtual planetarium

February's night-sky highlights with Paul Abel and Pete Lawrence



First light for a new era

Space telescopes show us the cosmos unimpeded by our planet's atmosphere – but, as these extraordinary new images show, ground-based telescopes are catching up

SPECULOOS, 5 DECEMBER 2018

The search for exoplanets is entering a new era, with the upcoming launches of the James Webb Space Telescope and the European CHEOPS mission joining the TESS satellite already in operation.

SPECULOOS (Search for habitable Planets EClipsing ULtra-cOOl Stars) is a new ground-based project consisting of four one-metre telescopes located

at the famous Paranal Observatory in Chile. The scopes will search for Earth-sized exoplanets orbiting ultra-cool stars and brown dwarfs, but these 'first light' images were released ahead of scientific operations to show what the instruments are capable of. They show familiar objects like the heart of the Carina Nebula (above), the Horsehead

Nebula (right, top) and the Southern Pinwheel Galaxy (right, bottom).

Now SPECULOOS will begin its search for Earth-like exoplanets orbiting in the 'habitable zones' around their host stars. If there is a planet similar to our own out there in the cosmos, perhaps this mission will play a major part in its discovery.



More
ONLINE
A gallery of these
and more stunning
space images

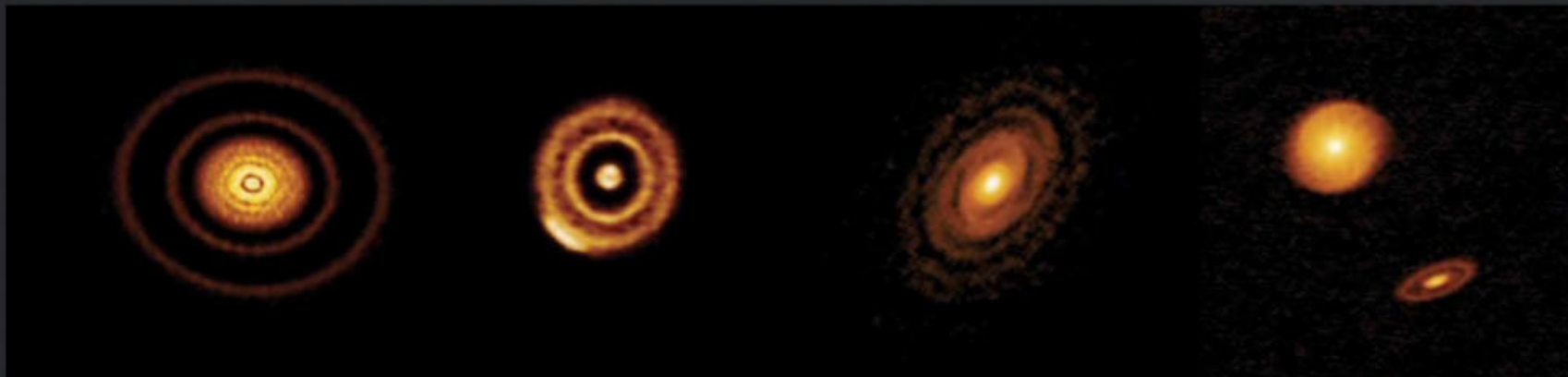




◀ Cluster calculator

HUBBLE SPACE TELESCOPE, 24 DECEMBER 2018

Globular clusters are among the oldest objects in the Universe. This one, named NGC 1466, is about 13.1 billion years old and has a mass the same as 140,000 Suns. Within this cluster are 49 known RR Lyrae variable stars. These have a known and constant brightness, so astronomers can observe their apparent brightness to calculate their distance.



△ Rings aglow

**ATACAMA LARGE MILLIMETER/
SUBMILLIMETER ARRAY,
12 DECEMBER 2018**

These bright rings are protoplanetary discs of dust and gas surrounding young stars: the regions where planets are born. The dark gaps are thought to be caused by newly-formed planets in orbit, carving the dust as they circle their host star.

High-velocity nebulosity ▶

**HUBBLE SPACE TELESCOPE,
31 DECEMBER 2018**

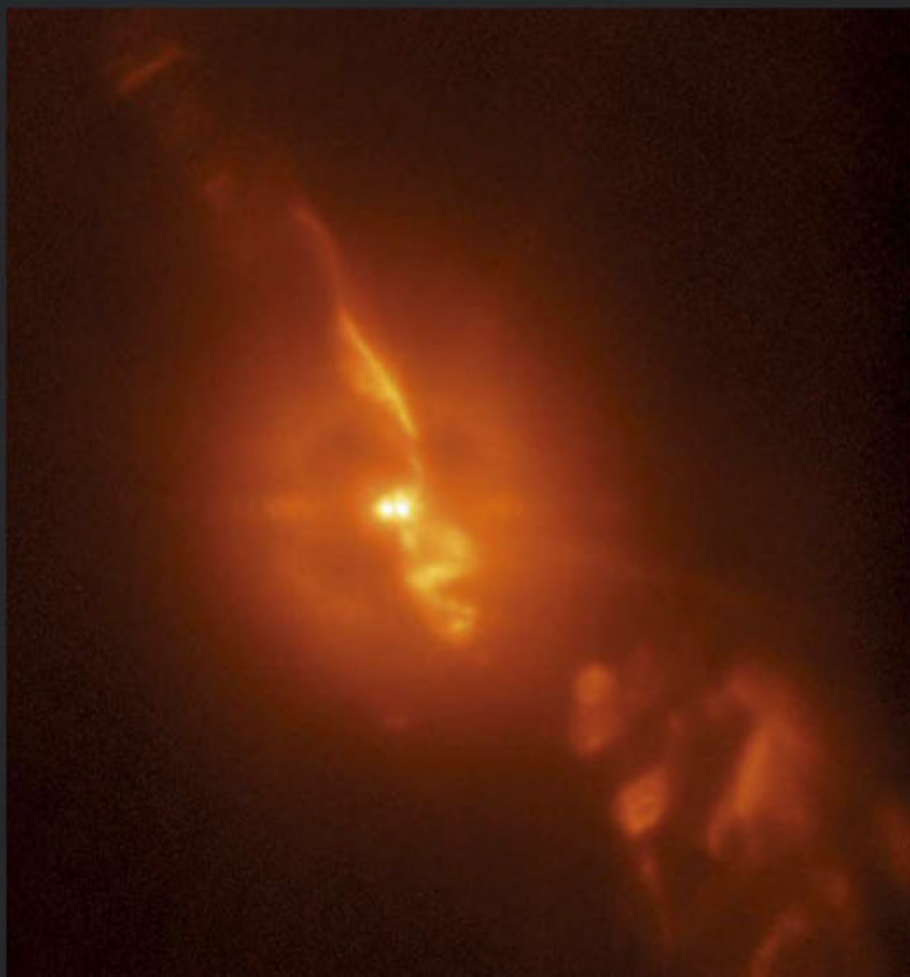
Herbig-Haro objects – the blue structures at the top of this image – are patches of cosmic cloud that form when jets of gas from young stars collide with nearby gas and dust. Herbig-Haros can reach speeds of 250,000 km per hour as they race away from their host star, but will eventually disappear after tens of thousands of years.



◀ Destructive duo

**VERY LARGE TELESCOPE,
12 DECEMBER 2018**

R Aquarii is a binary system made up of two stars that share a chaotic relationship. The larger is a red giant: a huge, ageing star shedding its outer layers into space; the smaller is a dense white dwarf that's stripping material from its red companion. The result of this cosmic dance is the huge, bright jets seen here stretching out into the void.



ESA/HUBBLE & NASA, ALMA (ESO/NAOJ/NRAO), S. ANDREWS ET AL./NRAO/
AUI/NSF/S. DAGNELLO, ESA/HUBBLE & NASA/K. STAPFELDT, ESO/SCHMID ET AL

The latest astronomy and space news, written by Elizabeth Pearson

BULLETIN



Comment

by Chris Lintott

Flyby encounters are special, and this one was especially dramatic.

When the formal press conference at which the first glorious pictures were shared came to an end, everyone just kept talking, and all you could hear were new questions: puzzles set by our first and only proper glimpse of this strange icy place.

The answers to all the scientists' questions are most likely in the data safely stored on New Horizons, which is already hundreds of millions of miles past Ultima. There will be no turning back, and it's unlikely another mission with return to Ultima Thule.

I was so pleased to have been there – flybys are over as quickly as they begin, but they're a lot of fun.

Chris Lintott
co-presents *The Sky at Night*



The most detailed image of Ultima Thule returned so far by New Horizons

New Year flyby for NEW HORIZONS

First glimpse of icy Ultima Thule, a remnant of the early Solar System

NASA probe New Horizons flew past the Kuiper Belt object Ultima Thule on 1 January 2019. The manoeuvre occurred 6.5 billion kilometres from Earth, making it the most distant flyby ever achieved.

The spacecraft originally flew past Pluto in 2015. It is now deep in the Kuiper Belt, a region at the edge of our Solar System filled with icy remnants from its formation, such as Ultima Thule. New Horizons passed the space rock at 05:33 UT on New Year's Day, at a distance of 3,500km and a speed of over 50,000km/h. The mission's operators then faced a tense 10-hour wait for the spacecraft signal to reach Earth.

"New Horizons holds a dear place in our hearts as an intrepid and persistent little explorer, as well as a great photographer," says Ralph Semmel, director of Johns Hopkins Applied Physics Laboratory (APL) where mission operations are based. "This marks a first for all

of us – APL, NASA, the nation and the world – and it is a great credit to the bold team of scientists and engineers who brought us to this point."

The spacecraft is now transmitting the flyby data back and researchers face another, longer wait. With download 20 times slower than a dial-up modem, it will take 20 months for full data retrieval. However, the first images have revealed that Ultima Thule is a contact binary, where two objects have touched and fused; that it's red in colour and as dark as potting soil.

"The data we have looks fantastic and we're already learning about Ultima from close up," says Alan Stern, Principal Investigator. "From here out the data will just get better and better."

<http://pluto.jhuapl.edu>

For more, see *Inside the Sky at Night*, page 16

NEWS IN BRIEF



Voyager 2 reaches interstellar space

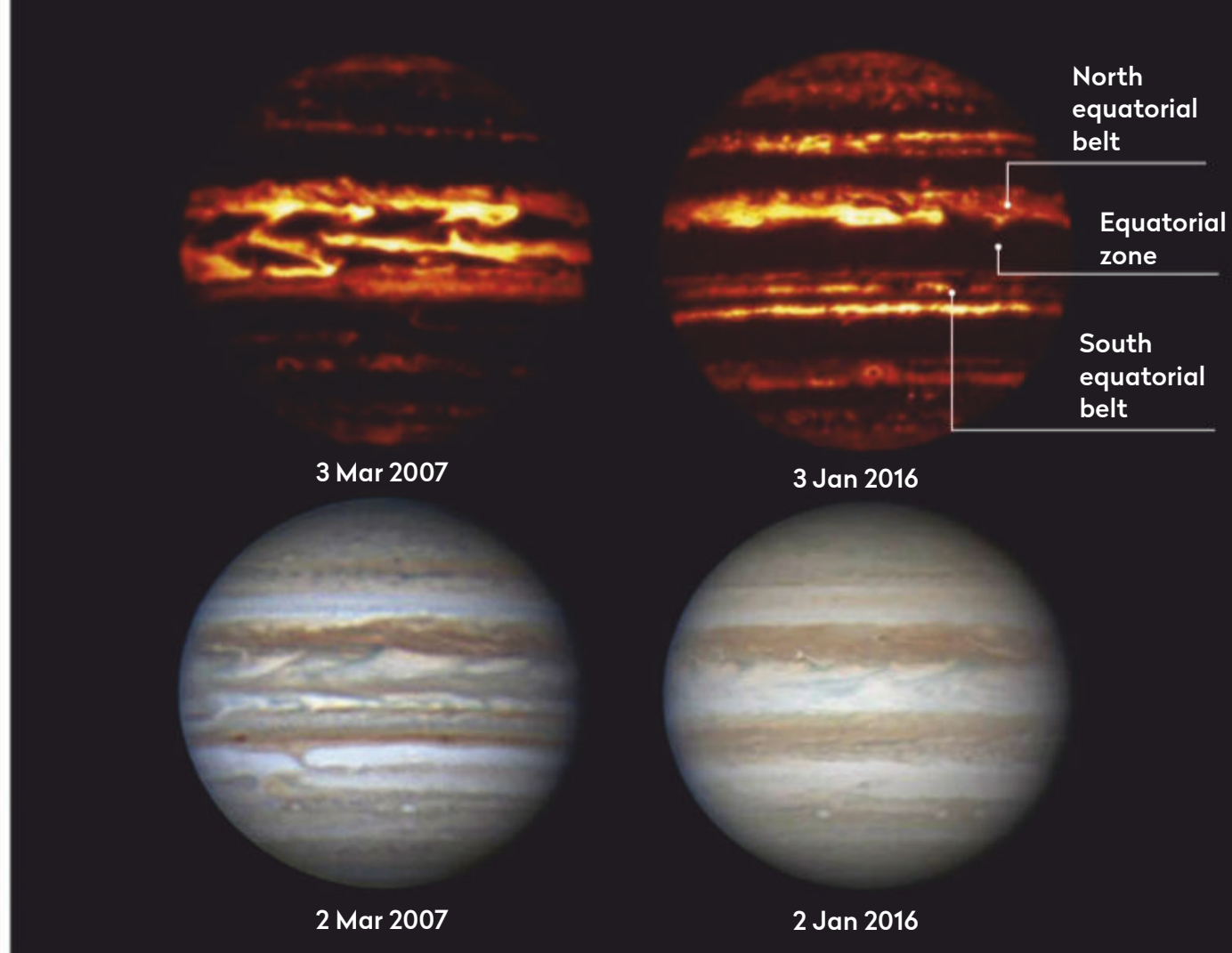
After travelling 18 billion kilometres, Voyager 2 has finally entered interstellar space. On 5 November 2018, the probe – which, unlike Voyager 1, still has a working Plasma Science Experiment – recorded a drop in solar wind, indicating it had left the Sun's magnetic bubble.

Black hole weaker than a fridge magnet

A new study has measured the magnetic field strength near a supermassive black hole. Astronomers found the field is stronger than Earth's, but still 10 times weaker than a fridge magnet – a surprise given it was thought magnetism was responsible for heating the plasma around black holes.

Water found on Benu

NASA's asteroid-investigating spacecraft, OSIRIS-Rex, has found water containing minerals across the surface of asteroid Benu. "When samples are returned to Earth in 2023, scientists will receive a treasure trove of new information about the history and evolution of our Solar System," says NASA's Dr Amy Simon.



▲ Images of Jupiter that illustrate the unusual disturbance of the planet's equatorial clouds during the last event in 2007. The cloud-clearing is due to happen again this year

Jupiter gets a new belt every seven years

The planet is due a change in wardrobe according to new research

Astronomers have uncovered a seven-year weather pattern around Jupiter's equator after looking at over 40 years of observations of the gas giant.

The study looked at infrared observations of a band of white cloud that usually circles the planet's equator. Most of the time this blocks infrared light, but the study found the

clouds cleared away every six to seven years.

"These cloud-clearing disturbances left the equator looking very bright in the infrared, and dark brownish in visible light," says Arrate Antuñano from the University of Leicester, who led the research. The pattern is due to repeat this year and the planet

already showed signs of darkening in late 2018. The team has called for astronomers, both professional and amateur, to keep an eye on Jupiter's equator, while the Juno spacecraft that's currently in orbit around Jupiter gets a close-up look at the phenomenon.

<https://le.ac.uk>

Star grows like a planet

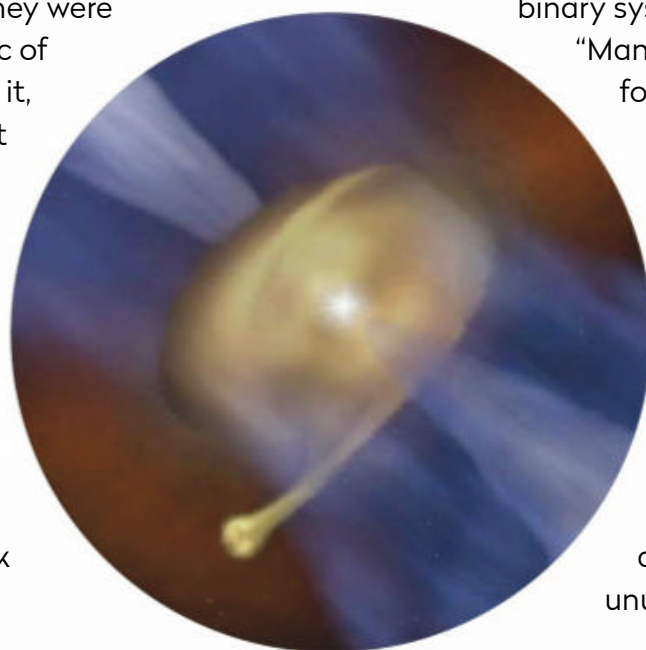
When astronomers imaged star MM 1a for a new investigation, they were aiming to observe the disc of dust and gas surrounding it, where they usually expect planets to form. Instead the team uncovered another star, MM 1b.

"It's great when the new data surprises you, which was definitely the case here," says Thomas Haworth from Imperial College London, who took part in the research. MM 1a is estimated to be around 40 times the mass of the Sun, while MM 1b is only half a solar

mass, meaning the pair are not a typical binary system.

"Many older, massive stars are found with nearby companions. But these 'binary' stars are often very equal in mass, and so are likely to have formed together as siblings," says John Ilee from the University of Leeds, who led the research. "Finding a young binary system with a mass ratio of 80:1 is very unusual and suggests an entirely different formation process for both objects."

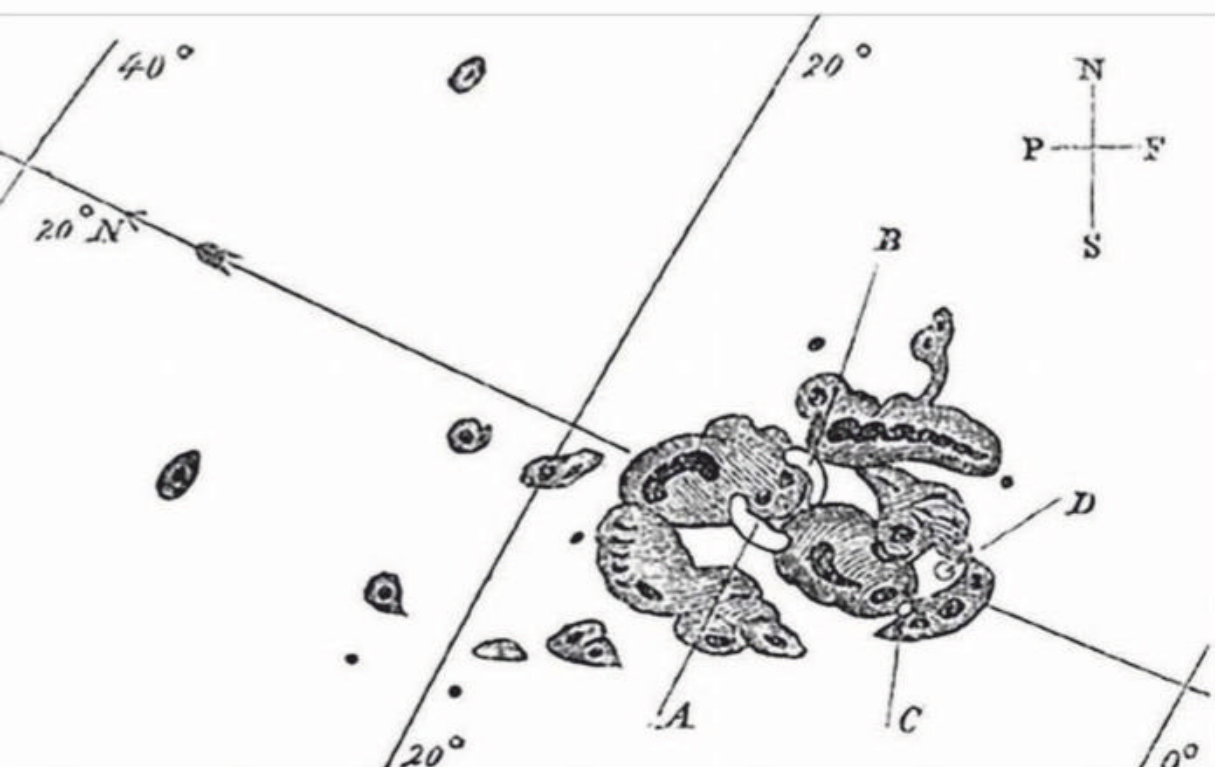
www.leeds.ac.uk



▲ Artist's impression of the dust and gas surrounding the massive star MM 1a and its unexpected companion, MM 1b

Our experts examine the hottest new research

CUTTING EDGE



◀ Sketches by Richard Carrington of the sunspots of 1 September 1859. A and B mark the initial positions of an intensely bright event, which moved over the course of five minutes to C and D before disappearing

well as historical documents such as diaries and chronicles from East Asia. He also gathered US Navy ship logs, and recently rediscovered articles in Mexican newspapers. One report from Zimapán, a small town in Mexico, described “a silver lily in the shape of an arc of a great circle” with “glowing rays extended downwards as if to meet a red light that shone up from the northern horizon”. The more intense a magnetic storm is, the closer to the equator the auroral emission oval pushes, and so geomagnetic field data can be estimated from these diverse reports on the elevation angle and direction of the aurora, as well as their colour.

The researchers found that the boundary of the main auroral oval, with multiple colours – glowing green, red, yellow and even white tints were reported

“If a large CME like the Carrington Event were to hit today, the consequences could be far more severe”

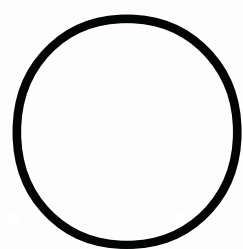
– pushed to a latitude of just 36.5° from the equator, whereas the limit of purely red emission was 30.8°. From this they estimated the penetration of trapped electrons and protons in Earth’s magnetic field.

These geomagnetic effects also occurred pretty promptly after the bright solar flare observed on 1 September – the CME appears to have travelled particularly quickly across the Solar System to Earth. Hayakawa and his colleagues think that the same patch of sunspots had launched an earlier CME on 28 August which had acted like a snow plough – clearing out interplanetary space so that the Carrington Event a few days later could slam into Earth without losing much energy, triggering a particularly extreme geomagnetic storm.

In the mid 19th century this intense geomagnetic storm caused disruption to telegraph wires. If a large CME like the Carrington Event were to hit our modern world – reliant as it is on vast electrical networks – the consequences to society could be far more severe.

Aurora archaeology

Researchers track one of the largest known solar eruptions 150 years after it happened



ne of the most intense solar storms ever observed occurred in 1859. On 1 September, the astronomers Richard Carrington and Richard Hodgson both witnessed an enormous white

light flare emanating from a large sunspot group. This flare apparently unleashed a coronal mass ejection (CME) directly towards Earth because within a day instruments around the world registered huge disturbances to the planet’s magnetic field, and aurora were seen much closer to the equator than normal.

The problem with trying to piece together exactly what happened during this ‘Carrington event’, and the precise magnitude of the effects on Earth, is that in the mid 19th century geomagnetic field measurements were much less sophisticated, and weren’t very widespread. So in a recent paper, Hisashi Hayakawa and his colleagues have tried to reconstruct the event from a wide range of eyewitness accounts of the unusual auroral displays and use them to estimate magnetic field data.

Hayakawa went back to reports collected across the western hemisphere immediately afterwards, as



Prof Lewis Dartnell is an astrobiologist at the University of Westminster and author of *Origins: How the Earth Made Us* (geni.us/origins)

Lewis Dartnell was reading... *Low-latitude aurorae during the extreme space weather events in 1859* by Hisashi Hayakawa et al. **Read it online at arxiv.org/abs/1811.02786**

▼ Enigmatic and ultra-diffuse, NGC 1052-DF2 continues to throw up surprises

Galaxy stays in the dark

A galaxy once thought to be devoid of dark matter might not be so empty after all

NGC 1052-DF2 is an unprepossessing name for the most controversial object in astronomy, a tiny galaxy with – perhaps – an unusual story to tell. Over the last year, astronomers from around the world have argued about a claim that this tiny system, much smaller than our own Milky Way, is devoid of the dark matter that astronomers think makes up the vast majority of the stuff in the Universe.

If this claim is true, then we need to rethink almost every modern theory about galaxy formation, or throw the most successful cosmological model in history out with the scrap.

But is it? The trouble with dark matter is that it's – as advertised – dark and can't be seen directly. Instead, we have to look at what we *can* see and infer the presence of dark matter from its movements. The study that kicked off the controversy looked at the velocity of the galaxy's globular clusters. They appeared to indicate that the galaxy's matter is accounted for almost entirely by what we can see.

Now a new team has taken a close look at the stars of NGC 1052-DF2 using an instrument called MUSE at the Very Large Telescope in Chile. MUSE is an integral field spectrometer, or IFU, a new kind of instrument capable of providing astronomers with many spectra at once. This means that, while previous measurements looked only at the globular clusters, this team was able to get a sense of how the stars in the main body of the galaxy are moving. And the results are intriguing.

The MUSE data shows evidence that the galaxy is rotating. That in itself isn't surprising – the main component of the Milky Way, for example, is a rotating disc. What's unusual here is that the disc is rotating around the long axis – rather than spinning a plate round and round, imagine it flipping over and over. That's not unheard of for small galaxies like this, but when you're trying to use how things are moving



“The team was able to get a sense of how the stars in the NGC 1052-DF2 are moving. And the results are intriguing”

as a careful tracer of the amount of dark matter that's present, it certainly makes life more difficult.

It also makes

understanding how this particular galaxy formed more complicated. Most suggestions revolve around an interaction with a neighbour – a merger or maybe just a result of the material in NGC 1052-DF2 being stirred by the gravity of a passing, larger neighbour. It could even be just the result of tides induced by the presence of such a companion. In any of these cases, the galaxy has had a messier past than many suspected, making it more difficult to measure the dark matter content as this technique relies on having an undisrupted, settled system.

The team also gained new confidence from their observations in which globulars are part of the galaxy, and even detected three planetary nebulae within the system. Putting these measurements together with what we know about the stellar disc produces a result consistent with a 'normal' proportion of dark matter. There's more to do, but modern cosmology survives. For now, at least.



Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also director of the Zooniverse project

Chris Lintott was reading... *The ultra-diffuse galaxy NGC 1052-DF2 with MUSE: I. Kinematics of the stellar body* by Eric Emsellem et al. **Read it online at arxiv.org/abs/1812.07345**

The latest astronomy and space news, written by Elizabeth Pearson

BULLETIN



Research suggests Saturn's icy rings are halfway through their lifetime

Saturn's rings are disappearing

We are lucky to have seen the spectacular rings at all

Saturn could lose its most unique feature, its rings, within 100 million years. A fresh analysis of the astoundingly thin ring system found that the ice it's made from is being pulled towards the planet by Saturn's gravity and magnetic field.

"We estimate that this 'ring rain' drains the equivalent of an Olympic-sized swimming pool from Saturn's rings in half an hour," says James O'Donoghue at NASA's Goddard Space Flight Centre. "Add to this the Cassini spacecraft detected ring material falling into Saturn's equator, and the rings have less than 100 million years to live."

The first hints that the rings were fading came from three seemingly unrelated phenomena discovered during the Voyager flybys in the early 1980s. The spacecraft detected disturbances in the upper layers

of Saturn's ionosphere, dark bands at mid latitudes and density fluctuations in the planet's rings.

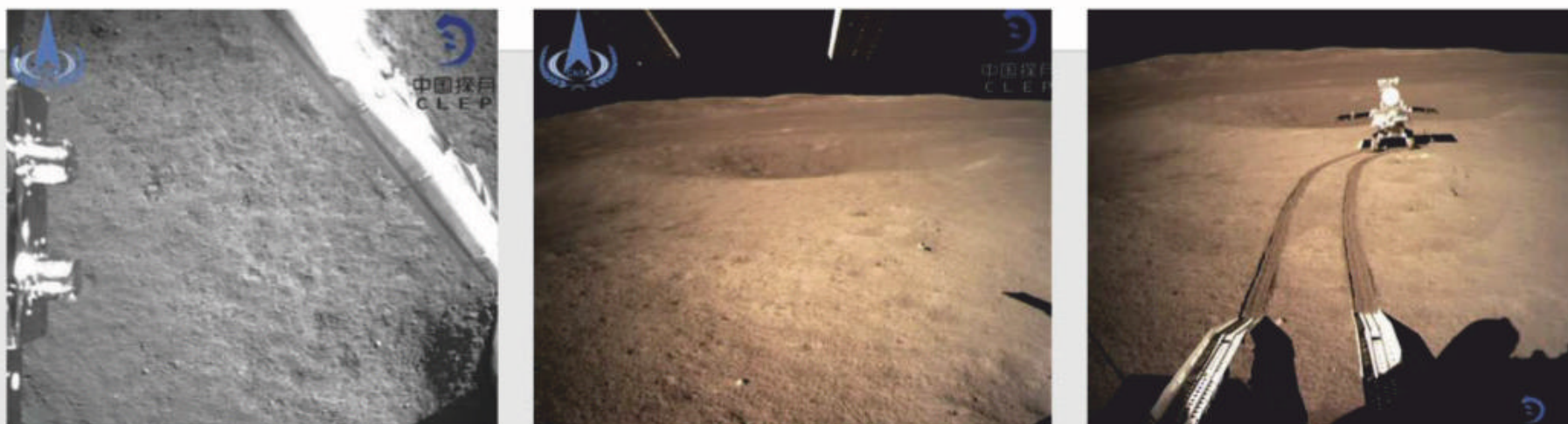
It was later suggested that the ionosphere variations were showing the shape of Saturn's magnetic field, and this in turn suggested that water was being pulled along magnetic field lines onto the upper atmosphere, where they washed away the haze, making the clouds appear darker.

The current study explored this theory by using the Keck Telescope to observe the gas giant and measure the rate of water falling onto Saturn. The find could help solve the century-old question of whether the rings formed at the same time as Saturn, or were created later. The rate at which the rings are dispersing suggests that they have only been around for a few hundred million years, meaning they

probably formed relatively recently in Saturn's four-billion-year lifespan.

"The young age of the rings has some really startling implications. It is possible, in the age of the dinosaurs, that Saturn's rings were even larger and brighter than we see them today," says Tom Stallard from the University of Leicester, who took part in the study. "Something dramatic must have happened around Saturn to make them this large, long after the planet itself formed."

"We are lucky to be around to see Saturn's ring system, which appears to be in the middle of its lifetime. However, if the rings are temporary, perhaps we just missed out on seeing giant ring systems at Jupiter, Uranus and Neptune, which have only thin ringlets today!" says O'Donoghue. <http://le.ac.uk>



▲ The first images of the Moon's far side from China's Chang'e-4 probe, showing the landing, the surface and the Yuta 2 rover

Chang'e-4 lands on the far side of the Moon

An on-board rover will help explore the previously unvisited region

China's Chang'e-4 lunar lander made a historic touchdown on the far side of the Moon at 02:26 UT on 3 January 2019. This is the first time a soft landing has been achieved in this region.

The mission launched on 8 December 2018. After a month of orbiting, the spacecraft dropped the lander into the Von Karman Crater in the South Pole-Aiken Basin.

Shortly after touchdown, the Chang'e-4 probe sent back the first ever images from the lunar far side and the Yuta 2 rover that accompanied the lander has already begun to explore the rocky terrain. Together the rover and lander will investigate the composition and structure of the lunar surface.

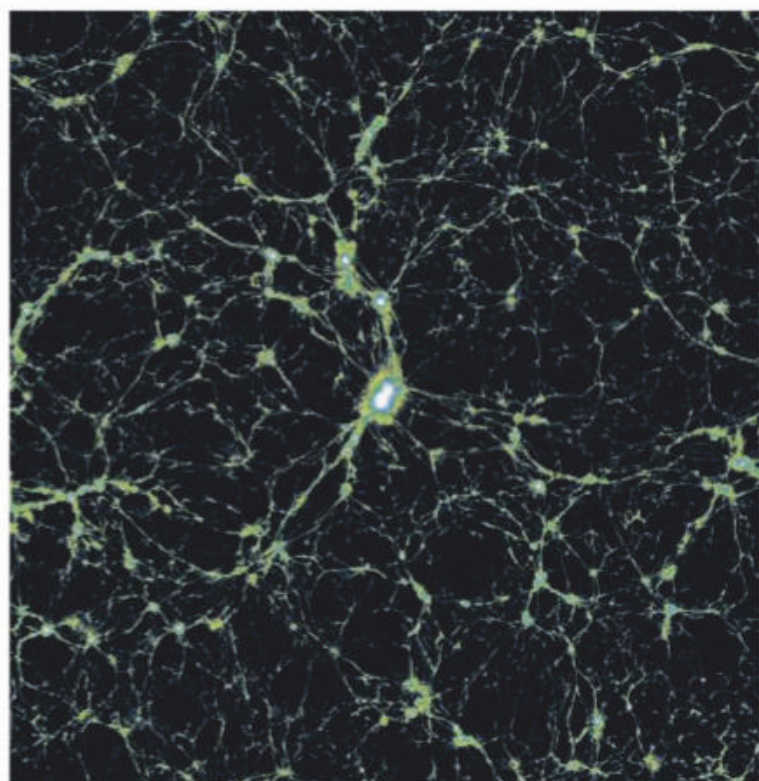
The lander also holds a sealed experiment containing plant seeds and

silkworm eggs, along with air and nutrients to test whether it is possible for living organisms to form a viable biosphere on the Moon's surface.

Communication with Earth, however, is complicated by the fact that the body of the Moon blocks radio signals. Instead, data will be relayed via the Queqiao orbiter that was launched in May 2018.

www.cnsa.gov.cn

Relic of the Big Bang found, from a time before stars



▲ A simulation of the rare, apparently 'pristine' gas cloud discovered – a relic of a Universe before stars

New observations have revealed a cloud of gas in the early Universe that has remained unchanged since the Big Bang, giving astronomers a window into what the Universe may have been like before stars formed.

"Everywhere we look, the gas in the Universe is polluted by waste-heavy elements from exploding stars," says Fred Robert from the Swinburne University of Technology, who led the study. "But this particular cloud seems pristine, unpolluted by stars even 1.5 billion years after the Big Bang."

The team examined the cloud by looking at a quasar behind it with the Keck Observatory in Mauna Kea, Hawaii. As the quasar's light travels through the gas, certain wavelengths get absorbed. Each element leaves a different shadow on the light, letting

astronomers determine what gases are in the cloud. In this case, the astronomers found no traces of heavy elements within the cloud.

Similar gas clouds have been detected previously, but they were found by chance. In this case, the group studied quasars that had previously been found to be lacking heavy elements. The successful find means that astronomers now have a way to conduct a targeted search for such clouds, and should find more in the future.

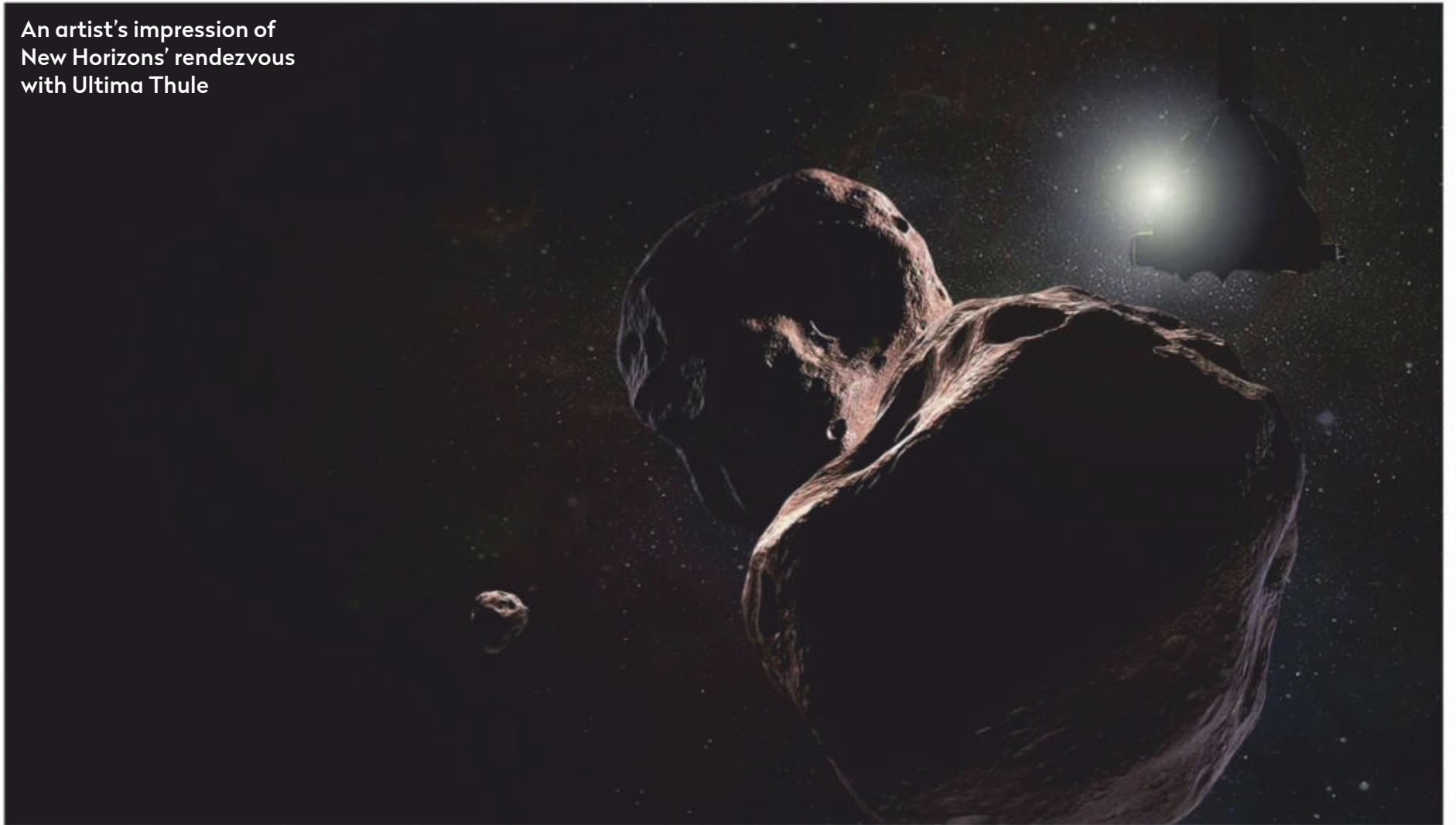
"That will tell us exactly how rare they are and help us understand how some gas formed stars and galaxies in the early Universe, and why some didn't," says Michael Murphy from the Swinburne University of Technology.

<http://keckobservatory.org>

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

An artist's impression of
New Horizons' rendezvous
with Ultima Thule



January's *The Sky at Night* reported on NASA's extraordinary encounter with Ultima Thule. **Carly Howett** from the New Horizons team tells us more

At 7.33am UK time on 1 January 2019, a small NASA spacecraft made its closest approach to the most primitive object ever explored. The craft, New Horizons, is on its post-Pluto mission to explore other inhabitants of the distant region of the Solar System known as the Kuiper Belt. The object, nicknamed Ultima Thule, is believed to be unchanged since its formation billions of years ago, and will provide unprecedented insight into how our planetary system formed.

The images returned by New Horizons show Ultima Thule to be a red, bi-lobed object with one lobe (Ultima) bigger than the other (Thule). These features combine to make it appear like a rusty version of the Star Wars BB8 droid!

The fact we have any images at all is somewhat remarkable, New Horizons is travelling at 14 km/s (32,000 mph) taking data of a target that's only 33 km (21 miles) across from a distance of 3,500km (2,200 miles) away. That's like taking a picture of a house about 2 miles away while being driven in a car travelling at 320 miles per hour.

Ultima Thule appears to be dark, lumpy and pretty uniform in colour, except in the neck region that links the lobes, which appears brighter and less red. As the Sun is almost directly behind the spacecraft there are few shadows, making it difficult to understand the topography of Ultima Thule (including whether any of the lumps are actually craters). This geometry could also explain why the neck appears bright: the neck is a gravitational well, so small particles will naturally end up there, which is likely to make it smoother and brighter than the rest of the surface.

When Ultima met Thule

Ultima Thule's appearance is already telling us a little of how it might have both formed and evolved. Our current thinking is that when our Solar System was forming, about 4.5 billion years ago, its outer regions were covered in the gas and dust of our early Sun's rotating protoplanetary disc. This disc wasn't completely uniform: some localised regions (like where Ultima Thule formed) had more dust relative to gas. These dust pockets would be gravitationally attracted to one another and stream through the gas



Dr Carly Howett is the Deputy Principal Investigator of the Ralph instrument on New Horizons and an expert on the surfaces of icy worlds

to form larger clumps, which in turn were able to attract more dust. This process is known as gravitational instability, and probably resulted in the formation of many objects including both Ultima and Thule.

If Ultima and Thule were the largest objects formed in their local system then as they spiralled into one another they could have imparted their rotational energy (angular momentum) into any smaller objects also formed in that system, booting them out. This loss of rotational energy would have allowed Ultima and Thule to finally come together, probably at very low speeds (think walking pace) and

early in our Solar System's formation; they have remained together ever since. The fact the two lobes have the same colour supports this theory, implying they have a common origin and evolution.

Our understanding of Ultima Thule is just beginning, however. Only a small fraction of the data on board New Horizons has been analysed. Over the next few months, as higher-spatial resolution images and spectral information is downlinked, and formation models are tweaked and tuned we will know Ultima Thule's shape, colour and composition along with the implications for its own and our entire Solar System's formation. So stay tuned! 📡

Looking back The Sky at Night

11 February 1966

On the 11 February 1966 episode of *The Sky at Night*, Patrick Moore investigated an intriguing event that had occurred just a few weeks earlier, on 24 December 1965.

As the residents of Barwell, Leicestershire were getting ready for Christmas Eve, a flash ripped through the sky followed by a loud bang. A few moments later, the entire village was showered with rocks: a meteor had exploded overhead.

Over the next few weeks, meteorite hunters flocked to Barwell to search for the space rocks, including Patrick. He

was lucky enough to find his own lump of meteorite, and offered it to a local museum. "They told me 'we have plenty of it, so you can keep it for display as long as you make sure it comes to us in your will,'" he said later.

One person not so happy with the Christmas visitor was Barwell resident Percy England, who found a meteorite sitting in the dent it had made in the bonnet of his brand-new car. When insurance refused to pay out, citing an 'Act of God', local legend has it that Mr England

went to a local priest asking for compensation. None was paid.



▲ One of the thousands of meteorite pieces to hit Barwell in Leicestershire



COSMOLOGY IN CRISIS?

Ever since we discovered that distant galaxies are racing away from us, there has been a huge undertaking to calculate how fast the Universe is expanding. Two very different viewpoints have emerged. *The Sky at Night* meets leading astronomers and cosmologists on both sides of this debate. Which team has the right answer? Could both be right?

BBC Four, 10 February, 10pm (first repeat

BBC Four, 14 February, 7.30pm)

Check www.bbc.co.uk/skyatnight for subsequent repeat times



▲ The brightness of cepheid stars is used to measure the Universe's expansion rate

Emails – Letters – Tweets – Facebook – Kit questions

INTERACTIVE

Email us at inbox@skyatnightmagazine.com

MESSAGE OF THE MONTH

This month's top prize:
four Philip's books



PHILIP'S The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2019 Stargazing*.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Passing on the passion

My five-year-old son is very interested in astronomy and this is largely attributed to you! Excitement mounts when your magazine comes through the post, and he usually makes me go straight to the monthly highlights section and 'The Big 3' so we can get our observing planned for the month ahead.

We started off by looking up at the stars and understanding how everything moves a little more each night, and he can now use your star chart with relative accuracy. He prefers my binoculars on a stand over my scope because of the field of view they offer, and was amending his Christmas list after we read your 'Six of the Best' binoculars review (December 2018 issue).

Here is a drawing he did before Christmas of Santa's reindeer going on a mini tour of the Solar System. He wanted me to explain that the



▲ Thanks to young astronomer Taylor for his picture explaining Santa's galactic route

ring around Mars is actually the route the reindeers take. The blue rectangle is an asteroid, by the way. You've got another five year old hooked on astronomy and, as far as I'm concerned, that's what it's all about!

Adam and Taylor Delmage, via email

This is delightful to hear, Adam, and why we produce the magazine. Thanks! – **Ed**

Tweets



Ian Carruthers

@HurricanesArt • 3 Jan
Gentle waves and starlight.
Portrane, North County Dublin
[@LovinDublin](#) [@PhotosOfDublin](#)
[@DiscoverIreland](#) [@IrishTimes](#)
[@deric_tv](#) [@skyatnightmag](#)



Button quick fix



I've bought a few of the Sky-Watcher Wi-Fi dongles for members here at the Sunderland Astronomical Society. Generally they have been

received positively, although one recurrent comment is that the direction keys lack the 'feel' of the standard handset: to hit the right one you need to look away from the eyepiece whilst aligning objects in the field of view. My simple solution is the use of sticky 'soft-closing' pads commonly sold for use on cupboard doors. These are

stuck on the tablet screen over the movement keys and have a feel that some say is superior to the old handset (there is minimal, if any, impact on the general use of the tablet once they're taken off). Your readers might find this useful; the buttons are inexpensive and widely available.

David Ettie, via email

Learn the sky!

As a 72 year old, I have been a reader of your magazine since its inception and have watched *The Sky at Night* on television since the first broadcast in 1959. Over the years, I have seen many changes and advancements in both professional and amateur astronomy. It now seems to me that whilst we have gained much, we have also lost. Today with 'Go-To'

TALES FROM THE EYEPIECE

Being able to step outside and gaze at the Moon is a given, but stepping outside and seeing a comet with the naked eye is a rare treat. To do so with a comet that stays visible to the unaided eye for months, as Hale-Bopp did, is extraordinary. When it became naked eye in 1997 it was almost as though a great unveiling had taken place.

That year I showed my parents Hale-Bopp, and while it was a fuzzy blob, it was a naked-eye fuzzy-blob: a world of difference from a telescopic fuzzy-blob. Its visibility brought astronomy to people who had never seen a comet before, showing you can never underestimate the importance of an object achieving naked-eye status.



Email your tales to Jon at TalesfromtheEyepiece@themoon.co.uk
Jonathan Powell is the astronomy correspondent for the *South Wales Argus*

telescopes, the need to learn the sky has almost gone. The joke used to be that professionals needed setting circles on their telescopes to find the Moon; today this is often the case with amateur astronomers. Also, with the advent of CCD cameras and stacking software, we no longer fully use that most important bit of kit, the Mark 1 Human Eyeball.

To my mind, nothing beats seeing a celestial object for real rather than on a computer display. After all, if one wants to have a superb picture of, say, Jupiter or Saturn then why not just get the picture from a book or the internet? I would urge all readers to do two things: firstly, learn the sky and secondly, see it for real. Perhaps I should add another... wrap up warm as well!

Terry Byatt, Spalding ▶



ON FACEBOOK

WE ASKED: What are your favourite memories of observing over the years?

Andrew Knight

With my friend Phill Froggett, enjoying his dark skies and doing some binocular observation whilst our cameras were clicking away.

Dave Hornby

Seeing the Milky Way at dusk, a green fireball whizzing across the sky, and detecting Orionids via radio astronomy over a cloudy weekend.

Kev Lowe

That moment when a member of the public looks through the eyepiece at Saturn for the first time and breathes "WOW!"

Keith Moseley

Having several hundred school

pupils, including visitors from Japan, watching the partial solar eclipse in 2015 from Monmouthshire.

Alan Davidson

My main memory is the cloud cover during almost every eclipse, meteor shower, etc.

Stuart Gasson

The first time my cousin touched a scope he found the Andromeda galaxy like he was lining up with the full Moon. First time both of us had ever seen it.

Phil Jones

With Kernow Astronomers, we witnessed a shooting star that left a 'vapour trail' that we could see for several minutes!

SCOPE DOCTOR



Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

Are the SkyMaster 25x70 binoculars good for imaging and observing, or would you recommend another pair?

ANDY MORELLO



▲ **Mounting is key for SkyMaster's 25x70s budget binos**

issues in some samples too, although that can be improved using the small adjustment screws underneath the rubber armour. However, binoculars with this magnification have to be mounted or the wobbly views will make observing uncomfortable and unsatisfying.

Staying at the budget end of the market, as you would have to pay considerably more to better them, a pair of 15x70 binoculars would be the better choice, as their brighter views and more manageable magnification make them far more enjoyable to use. Make sure to check the collimation when you receive them and accept that these too will have been stopped down. Omicron, Orion and SkyMaster all produce 15x70s that would be suitable options. Remember, if you are imaging through your binoculars you will need a stable mount for them.

The SkyMaster 25x70s are a budget pair of binoculars representing amazing value for money, but there are some caveats to purchasing them. In common with many binoculars around this price point, they are stopped down at the prisms, so their real aperture is more like 63mm. There can be collimation

Steve's top tip

What are diffraction spikes?

Light from bright objects like stars is diffracted when it passes any straight edge in its path and this diffraction manifests itself as bright spikes extending in two directions from the core of a star. For example, the spider vanes that support the secondary mirror in a Newtonian reflector each produce two spikes, although with the normal four vanes you only see four spikes because the second four are neatly overlaid on top of the first four!

Widefield images captured using a camera lens often show multiple diffraction spikes caused by the leaves of the camera's aperture iris, so a seven-leaf iris will produce 14 spikes.

Steve Richards is a keen astro imager and an astronomy equipment expert

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SOCIETY IN FOCUS

Caithness Astronomy Group (CAG), the most northerly sky-watching society on the British mainland, celebrated its 10th anniversary in style in December with a presentation from Prof Martin Hendry MBE, Head of the School for Physics and Astronomy at the University of Glasgow.

Martin made the 800km round trip to bring us up to speed with the latest space science, the detection of gravitational waves and the applications these may have for further study of our astonishing Universe.

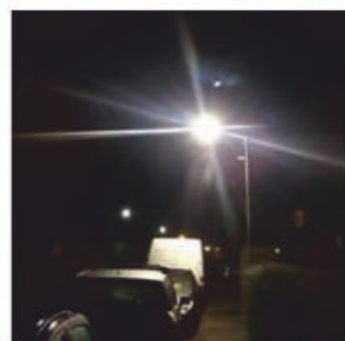
CAG was formed by a small group of astronomy enthusiasts in 2008. As well as being a forum for amateur astronomers to observe, share knowledge and help one another with equipment, we've also sought to spread astronomical interest to the public. In that first year alone we attracted



over 700 attendees to events and have since initiated well over 100 more, as well as participating in science festivals in Caithness and Orkney. You can't have a birthday without a cake, and we shared ours with Professor Hendry, who demonstrated that, in addition to being at the cutting

edge of modern astronomy, he's also a dab hand with a large knife. Tribute was paid to CAG chairman Gordon Mackie, whose effort and enthusiasm has been fundamental to CAG's success over the years. The only fly in the ointment was the weather – horizontal rain and thick cloud cover obviated our evening's observing! www.facebook.com/CaithnessAstronomyGroup
Jim A. Johnston, Caithness Astronomy Group member

Let there be dark



After reading 'Dark Matters' (Field of View, January 2019), I couldn't help but think of my own predicament. For much of

the last 20 years I have enjoyed back garden astronomy with only the minor irritation of a sodium street lamp. Last winter the old light gave up the ghost and I had many great nights observing an uninterrupted night sky with little sign of light pollution. Eventually the street lights were replaced by LED units, which were brighter than the sodium lights and not shrouded as we were promised. They had defective daylight sensors: some would stay on 24 hours a day while others (including the one that shone into my garden) didn't light at all.

I was just starting to enjoy the situation when the faulty unit was replaced with one removed from the local highway. The light is so bright I couldn't recognise my next door neighbour while being dazzled by it! The photo shows the light (the ¾-lit Moon can be seen above it – just). Now I can see the full Moon, Sirius and Venus

but virtually nothing else. This time last year I was preparing for my upcoming retirement by planning the purchase of a new telescope and astrophoto equipment. But back garden astronomy is a thing of the past now: to see anything of the night sky I have to take the dog for a long walk, away from the new lighting.
George Futers (former amateur astronomer), Peebles

Tweets



Paul Martin
@Tyrone_skies • 5 Dec
Comet 46P/Wirtanen finally revealed itself on Monday night after some bad observing weather. Here's me and the guys in action with telescope and binos @VirtualAstro @ukyoungastro @StormHour @BBCStargazing @skyatnightmag @TheUniverse_TM



HOW TO PICK YOUR PERFECT NORTHERN LIGHTS HOLIDAY

A mesmerising and spellbinding celestial light show that has fascinated humankind for millennia; the Aurora Borealis is Mother Nature's greatest spectacle and is one of those epic travel experiences that simply should not be missed.

This is your guide to choosing the perfect Northern Lights holiday with The Aurora Zone, the only holiday company solely dedicated to helping you tick the Aurora Borealis off your bucket list.



1 WHEN YOU SHOULD TRAVEL

Although the Aurora Borealis occurs throughout the year, these shimmering ribbons of light are only visible to the naked eye once summer's Midnight Sun has faded. During the darker months of the year, from late August through to early April, you can witness the Aurora's hypnotic dance in the Arctic skies.



2 WHERE YOU SHOULD TRAVEL

The Northern Lights appear most frequently at a latitude of approximately 66°N - 69°N; an area known as the Aurora Zone. Within this zone, whether you're in Finland, Sweden, Norway or Iceland, you will need to escape the artificial lights of large cities and ski resorts for dark starry skies to maximise your chances.



3 HOW TO HUNT THE NORTHERN LIGHTS

To maximise your chances of seeing the Aurora, find a holiday that includes multiple Northern Lights hunts. Mobility is key to outrunning any obscuring cloud cover, so try travelling by snowmobile, keeping warm in a minibus, or even reach new heights in a plane, and remember nobody knows the vantage points better than an expert local guide.



4 HOW TO SPEND YOUR DAYLIGHT HOURS

The Northern Lights may be your focus, but the daytime hours can be just as memorable. Experience an array of sub-zero escapades; tick husky sledding off your bucket list, snowmobile across winter-white landscapes, enjoy whale watching in Norway's fjords, discover UNESCO sites, or explore the snow-capped forests during a reindeer-pulled sleigh ride.



5 WHERE TO STAY

Why not stay somewhere that's just as memorable as the winter wonderland that surrounds you? Choose between traditional log cabins, hotels made of ice and snow, wilderness lodges and remote hotels. Better still, stay in specialised Aurora accommodation with a glass roof; you might just experience the Northern Lights from the comfort of your bed!



6 ASK AN EXPERT!

Expertise and knowledge are key to witnessing the Northern Lights and our Aurora Experts have over 16 years' experience. They have explored the best destinations, researched the science and built up an extensive network of expert guides. With over 90 dedicated Aurora tours, our experts are on hand to help you pick your perfect trip.

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NGC7635 image by Gordon Haynes www.imagingtheheavens.co.uk



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*Occasionally we will be closed on Saturdays for major events such as Astrofest, Practical Astronomy Show or Star Parties

The Widescreen Centre Spring Events 2019

The Widescreen Centre will be at the following events in early 2019:-

- Astrofest in London, February 8-9th in Kensington Town Hall. Booths 11-14 on the Ground Floor. www.europeanastrofest.com
- Practical Astronomy Show, March 9th at Kettering Conference Centre, Booth F2. A new show with free entry. www.practicalastroshow.com
- Spring Equinox Star Party, April 5-9th at Kelling Heath on the North Norfolk Coast. Pitch 107, yellow field. www.starparty.org
- Our own events will resume at Easter but stay tuned for further updates. For email newsletter: simon@widescreen-centre.co.uk

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skyatnightmagazine.com/whats-on

If you want to tell the world about your event, fill in the online submission form



Family astronomy

Mills Observatory, Glamis Road, Dundee, throughout February

This month at Mills expect planetarium shows and a guide to navigating the night sky. A 'Saturday Stars' event invites the whole family to get involved in astronomy craft activities. Ticket info available at the observatory's website.

www.leisureandculturaldundee.com/mills-home

North Wales Astronomy Society

Conwy/Llandudno, 12/27 February

The North Walian astronomers meet on 12 February at Llanellian community centre for stargazing (weather permitting) and astronomy chat. On 27 February the society's lecture night at Llanrhos old school will see the University of Nottingham's Dr Julian Onions explore explosive events in the night sky.

www.northwalesastro.co.uk

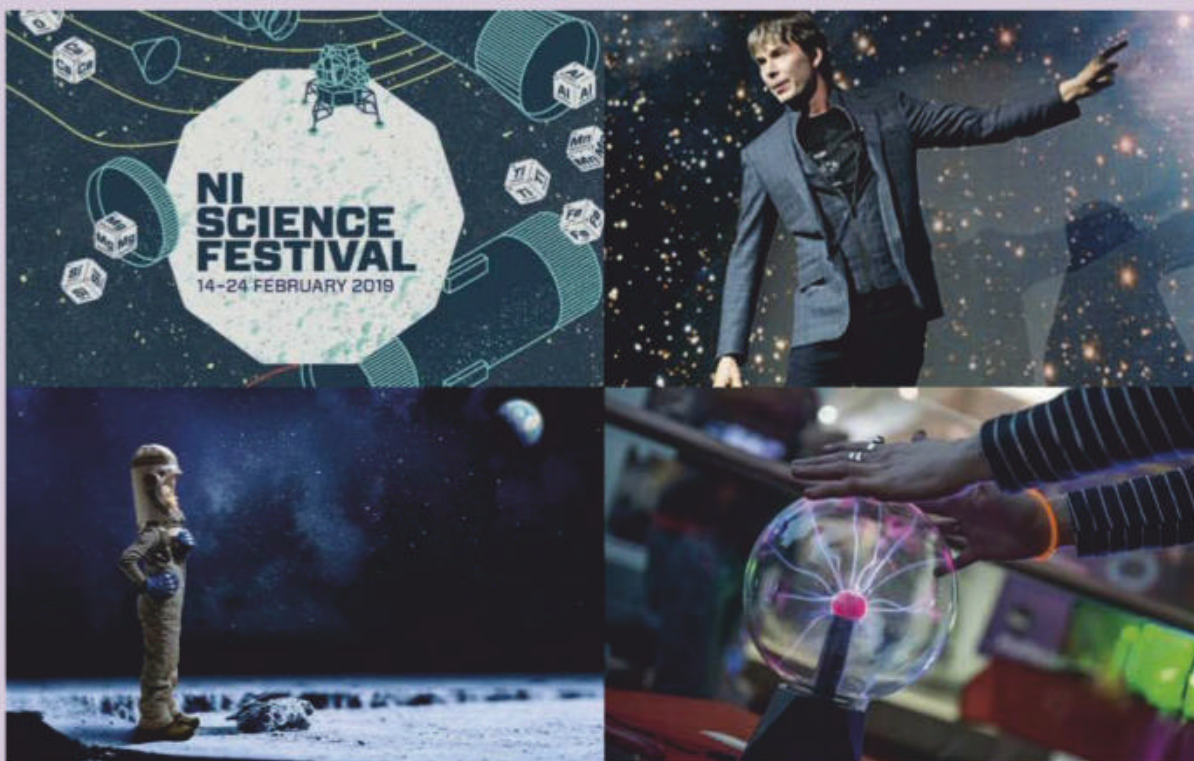
Aberdeen stargazing

The Bettridge Centre, Newtonhill, Aberdeenshire, 26 February, 7pm

Join the folks at Aberdeen Astronomical Society for an evening of observing the night sky through telescopes. If you're a beginner, bring your telescope along for help and advice from seasoned amateurs.

www.aberdeenastro.org.uk

PICK OF THE MONTH



▲ Space and astronomy take centre stage at this year's Northern Ireland Science Festival

Northern Ireland Science Festival 2019

Various locations, 14–24 February

The NI Science Festival returns for another year of talks, workshops and exhibitions, this year with a focus on astronomy and space to mark the 50th anniversary of the Apollo 11 mission. This includes Professor Brian Cox bringing his Universal World Tour to Belfast's SSE Arena.

At Queen's University Belfast, space science communicator Scott Marley presents an interactive journey through the astrophysics of the Solar System, while Simon Watt brings the science of space exploration to Titanic Belfast. At the city's Crescent Arts Centre, astronomer Robert

Massey and art historian Alexandra Loske present Moon: Art, Science and Culture.

Join the Irish Astronomical Association and Sirius Science at the Marble Arch Caves in County Fermanagh for outdoor stargazing, or head to the Armagh Planetarium for an 'After Dark' session in which guests will 'take over' the facility for planetarium shows, experiments and telescope observing (adults only).

There are over 200 events covering all areas of science at this year's festival. For information and tickets, visit the website:

www.nisciencefestival.com

Norman Lockyer open evening

Norman Lockyer Observatory, Sidmouth, Devon, 2 & 16 February, 7.15pm

Two open evenings include an astronomy presentation, a planetarium show and a tour of the historic telescopes. Observing will take place if the sky is clear. Tickets are £10 for adults and £5 for children.

www.normanlockyer.com

Observing Orion

Chalet Pavilion, Carding Mill Valley, Shropshire, 9 February, 8pm

Astronomer Pete Williamson hosts an evening celebrating winter's most famous constellation, Orion. £10 ticket price includes a bowl of soup.

www.nationaltrust.org.uk/carding-mill-valley-and-the-long-mynd



1000 PHOTOS WITHOUT ELECTRICITY

MiniTrack LX2: The First Fully Mechanical Photography Mount



Saslong Night - Sassolungo da Col Raiser (Italy) — Photo: Cristian Fattimanzi

Wide-field imaging, as depicted above, is possible with ease. The fully mechanical Omegon MiniTrack LX2 mount works just like a clock. No power necessary. No charging. No battery. Simply mount your camera onto the LX2 and wind it up. Easily capture wide-field images of the cosmos on your camera.

✓ Clockwork Mechanics

The mount works like a clock with 60 minute tracking - all without power and batteries. Simply wind it up and get started.

✓ Sleek and Compact

Whether on a flight or on the next night-time excursion. The MiniTrack fits into every bag and still leaves room for a nice tripod or a second tele-photo lens.

✓ Powerful Spring System

The MiniTrack requires no counterweight, the spring system supports tracking. Spare yourself the weight and burden.

✓ Integrated 1/4" Threading

The MiniTrack fits every photography tripod and features two 1/4" threads. For example, you can connect the MiniTrack to a ball head and capture every part of the night sky.

✓ Up to 2 kg Load Capacity

The mount enables you to capture wide-field images of the night sky. From wide-angle to tele-photo lenses, so much is possible.

✓ Polar Finder Tube

With the polar finder tube, you can calibrate the MiniTrack quickly to the polar star. More than enough for a rough alignment.



ball-head, camera and tripod not included!

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Photography Mount for the northern hemisphere incl. ball-head		
WxHxD in mm 210x78x130, weight 730 g	56106	139,00
NEW Photography Mount for the northern and southern hemisphere		
WxHxD in mm 250 x 78 x 30, weight 490 g	57993	139,00
NEW Photography Mount for the northern and southern hemisphere incl. ball-head		
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The Press says:

"The resulting star shapes were impressive, showing no sign of trailing ... We would recommend the MiniTrack to users of any experience level as a simple means of mounting basic imaging equipment for wide-field imaging." (BBC Sky at Night)

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FIELD OF VIEW

Things are looking up

Scott Levine recalls how the stars helped him bond with a suspicious neighbour



Scott Levine is an amateur astronomer and astrophotographer

My neighborhood is hilly and leafy, with wide stretches of the sky hidden behind rooftops and leafy branches. A rising Moon doesn't clear the houses across the street for hours after everyone else has finished oohing and ahing over how big it looks.

To get a better view, I sometimes like to stroll to the top of a winding cul-du-sac a couple of blocks away. If the lights there are low, the view across the river and far-off hills is spectacular. It's like being in a planetarium, with stars everywhere, only it's the real thing. Year after year, I've walked there. I walked there with my wife when she was pregnant and calmed her there when she was in labour. I walked with my daughters strapped to my chest (in one of those pouches, not with duct tape and bungee cords).

I've relaxed and thought through problems there over and over as, little by little, the grey hair crept into the sides of my head and the days'-old scruff around my chin. Quietly in, quietly out. It's a private universe; an astronomical no-wake zone.

After a long day a few months ago, I stood gawking at the Summer Triangle. A van pulled into a driveway

and stopped. "Hey," the driver shouted with anger or defensiveness, "Who are you? Why are you here? What's with that torch?"

"I'm Scott." I pointed towards my neighborhood and held out my hand. He didn't hold out his.

"Why are you here?" he demanded again.

I pointed up, "You've got a real gift here."


"What...? Oh..." His posture softened.

I pointed at Saturn, which was near the Moon that night, and traced the ecliptic. We star-hopped from Altair in Aquila, to Deneb in Cygnus to Vega, high overhead in Lyra. We started talking; about the sky, about life, about time passing. When he was a kid, he loved to look at the stars, he said, but as time went by, like so many of us for so many reasons, he just stopped. "I don't remember the last time I looked."

We could see distance and time, intimately connected functions of each other, right in front of us. The Moon is close, just a lightsecond and a half away. Saturn's 80 lightminutes off. Then, things get very far, very fast. The light from Altair left 17 years ago, when his oldest son was a baby, he told me. Vega's a bit farther, 25 lightyears. Deneb is among the most distant stars you can see with just your eye: its light left it over 2,000 years ago.

"But, what's that?" he asked, pointing to a faint haze toward the horizon. Just barely there, begging through the needless, wasteful, bright suburban lights, was the blur of the Milky Way, tens of thousands of lightyears away.

"Wow, I'm glad I stopped," he said, grinning over his understatement, and holding out his hand. "I'll check it out again tomorrow."

New friends and astronomy fans are everywhere. As he turned, I heard the door close behind him. I saw the flood lights over his porch and driveway blink out. 



BBC

Sky at Night MAGAZINE

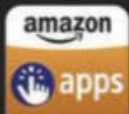
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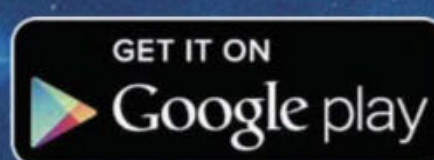
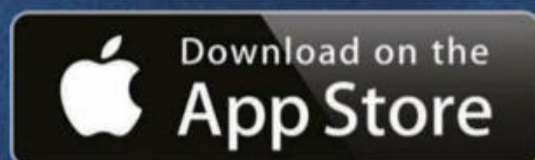
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PARTY under the STARS

Star parties are a great way to meet fellow astronomers under truly dark skies. **Jamie Carter** reveals what to expect and the top events this year





◀ Star parties offer the chance to try out new equipment and techniques with fellow astronomers



Jamie Carter is a well-travelled amateur astronomer and author of *A Stargazing Program for Beginners: A Pocket Field Guide*

Have you ever been to a star party? Many amateur astronomers spend the majority of their time alone, either studying the night sky or learning about it. However, there is one sure-fire way to learn more quickly and to get more out of astronomy, and that's to share the experience. Cue the star party, an annual (or more regular) observing event where like-minded people get together to share their interests and, very often, their eyepieces.

Like astronomers, star parties come in all shapes and sizes and there is no hard-and-fast definition. "The term 'star party' is used generally for many types of astronomy events and gatherings," says Kevin Smith, who helps organise the Skellig Star Party at the fabulous Dark Sky Reserve in County Kerry, Ireland every August. However, most have a purpose or theme and it's important to look up the event on the internet and social media to get a feel for what you are likely to experience before signing up.

For example, local astronomy clubs often hold monthly stargazing sessions that are frequently called 'star parties'. At the other end of the spectrum, there are star parties that go on for days or even as long as a week in some of the darkest parts of the UK and ▶

Astrophotography is a growing part of the star party experience

► Ireland. Even those events can vary, with some aimed at experienced amateur astronomers wanting to do some serious observing, and others more relaxed and focused on beginners. “Some star parties have been running for years, so it’s good to ask people who may have attended them before,” says Smith.

“Star parties are an in-depth crash course in astronomy,” says Ralph Wilkins, one of the organisers of AstroCamp, the biannual star party in the Brecon Beacons. “You can learn what’s in the night sky, what to find and get help finding an object. Star parties stop people from failing with telescopes, but also you get to know new people.”

It’s that idea of ‘social astronomy’ that inspired the creation of AstroCamp in the first place. “We’ve got a common area where all the telescopes are set up, and anyone can come along and spend the evening just wandering around from telescope to telescope, asking questions,” says Wilkins.

Party times

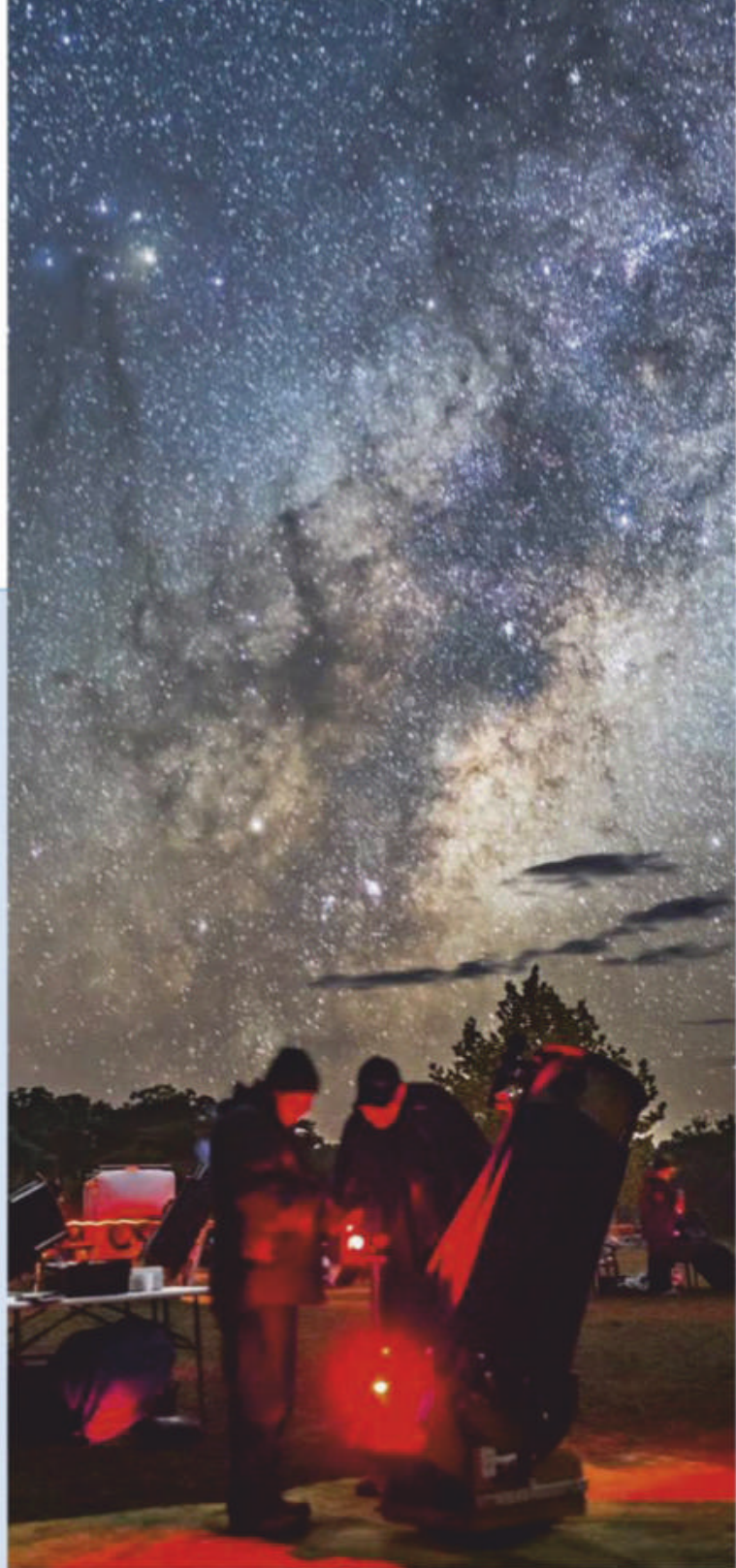
Most star parties have their origin in local astronomy clubs holding an annual event to do some observing. Occasionally they may coincide with an astronomical event such as a meteor shower, but often they’re timed simply to take advantage of the dark skies

With many telescopes set up to observe, you often don’t need to bring your own equipment

around new Moon. There tend not to be many star parties in the middle of summer because there are fewer hours of darkness. With longer nights as well as seasonal views of the Milky Way, spring and autumn are the most popular times for star parties.

There’s a common misconception that you must have a telescope to attend a star party. Not so, says

“With longer nights and seasonal views of the Milky Way, spring and autumn are popular times for star parties”



Astronomy etiquette

Avoid star party pitfalls with our guide to communal stargazing

DO

- ✓ Bring a warm jacket, hat and underwear (clear nights are cold)
- ✓ Use a red-light torch (pointed downwards) to preserve dark-adapted vision
- ✓ Take care around telescopes
- ✓ Bring a telescope and/or binoculars if you have them
- ✓ Socialise and share an eyepiece
- ✓ Bring and share drinks and snacks
- ✓ Have money for buying accessories from on-site sellers
- ✓ Be prepared for a wet weekend

DON'T

- ✗ Shine white lights and torches after dark
- ✗ Leave laptops and smartphones unattended
- ✗ Drive a car or turn on headlights after dark
- ✗ Look through a telescope without permission (it may be for astrophotography)
- ✗ Make a lot of noise at night or early in the morning

Smith: "People should be encouraged to turn up without a telescope and made to feel welcome if they don't have one. Most of our repeat attendees are people who turned up for the first time without a telescope or any astronomy knowledge."

If you have a telescope, bring it along, but you won't be expected to. In fact, if you are confused about telescopes, need some buying advice or just want to look through a telescope for the first time, there is no better place for you than a star party.

"You don't need a scope for your first star party. It's better to go to one to get some idea of what's out there and what's value for money," says Alan Beech, an amateur astronomer from Manchester and star party regular. "There will be plenty of educated people there willing to give you sound advice."

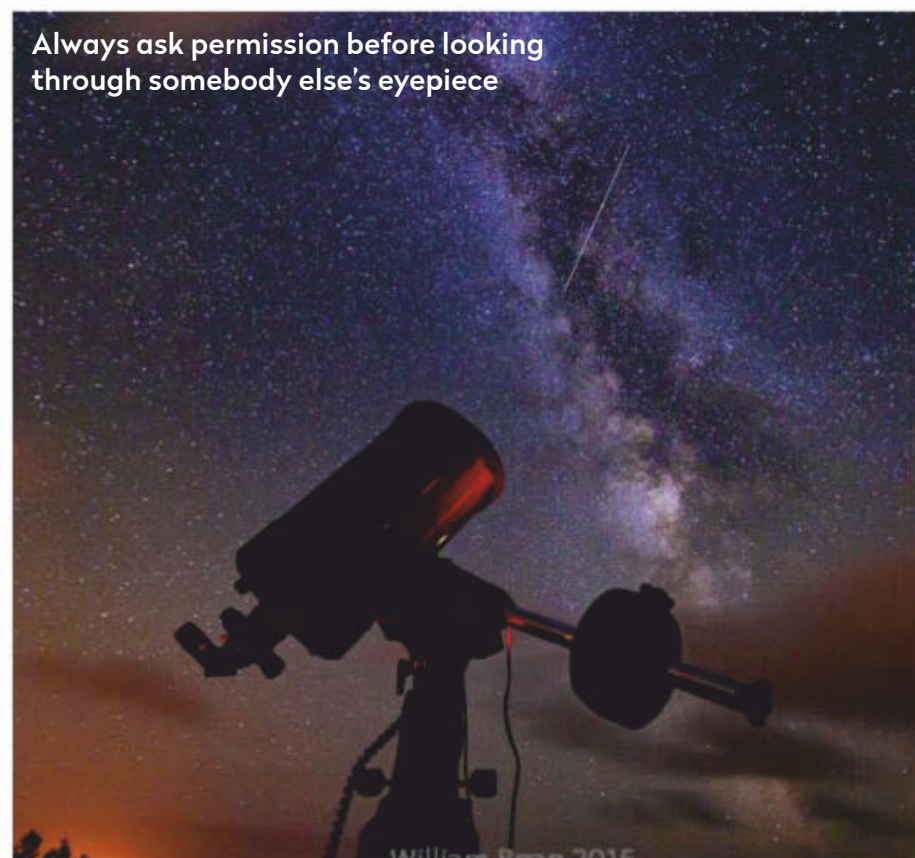
Star parties are such good places to audition telescopes that it is likely if you do turn up to your first one with a brand-new telescope, you'll leave wishing you'd spent your money on something else.

"Newcomers to astronomy can trawl the internet endlessly for clues, but nothing can beat putting your eye up to an eyepiece and seeing for yourself," says Neil Hawkins, owner of Tring Astronomy Centre, who attends many star parties. "A star party gives you the chance to see and try not just one, but usually 50 or more telescopes all operated by expert enthusiasts, usually very willing to help." However, if you do end up

sharing an eyepiece with someone for a few hours, it's polite to share something back. A beer or snack always goes down well.

Astrophotography has become a huge trend among amateur astronomers, so it's no surprise that star parties are responding to demand. "We have seen a phenomenal growth in astrophotography," says ►

Always ask permission before looking through somebody else's eyepiece





Don't feel overwhelmed by scope envy – the reason astronomers set these things up is so they can be admired and used by others

“Don't feel intimidated about going to your first star party, even alone, because astronomers are a friendly bunch”



Not some '80s *Doctor Who* monsters, but portable observatories, pitched and ready for use when darkness falls

► Smith. But the popularity of astrophotography does mean a few 'new' rules for star parties that perhaps haven't been important until recently.

“An astrophotographer does not want streaks of red light from torches in their wide-field images, so they often locate themselves in a different area to observers. Laser pointers may also be deemed inappropriate,” explains Smith.

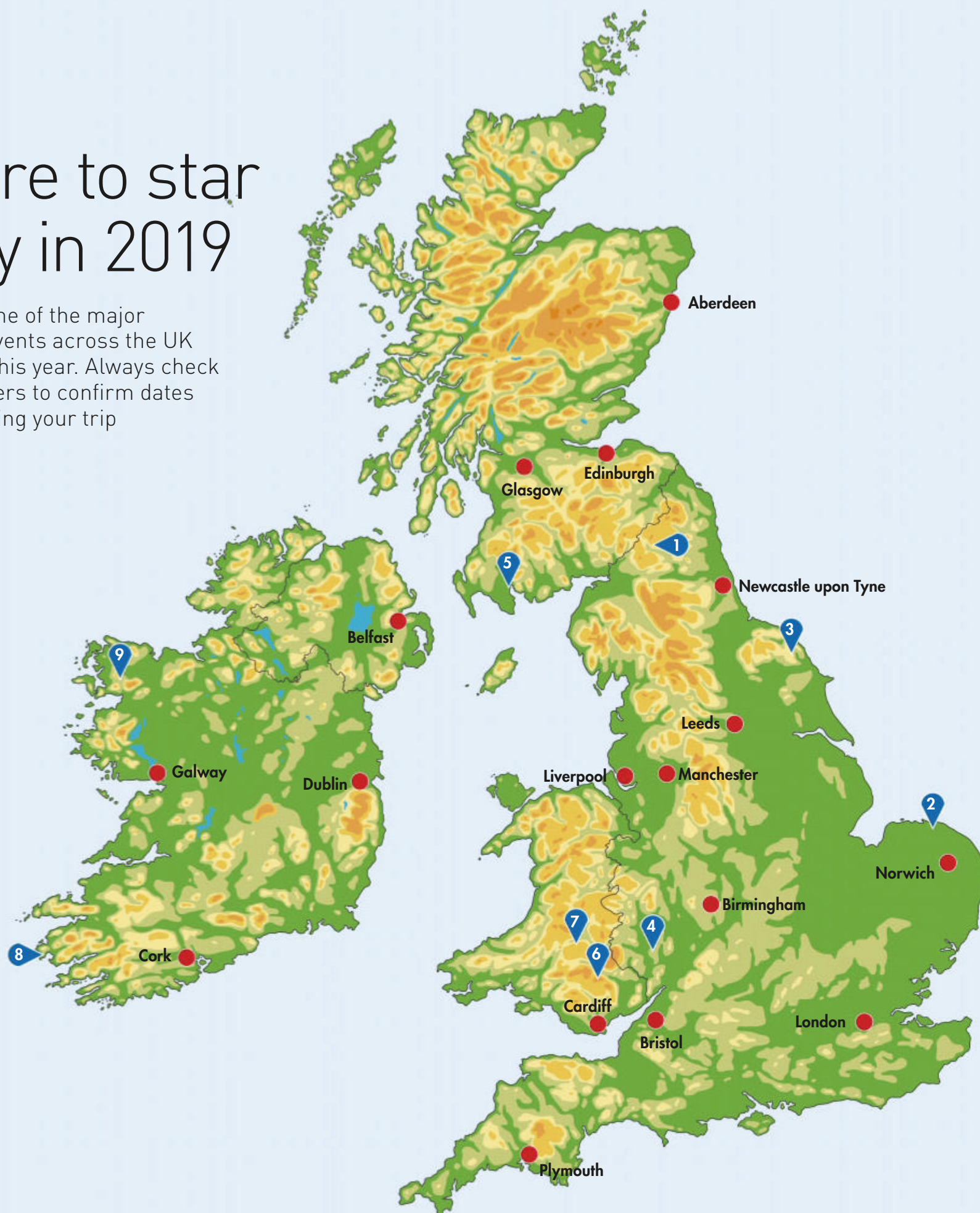
Other than that, star party etiquette is little more than keeping light to an absolute minimum, using red torches to avoid spoiling other people's dark-adapted vision, and being polite. Above all, first-timers should not allow themselves to feel out of place.

“We know a lot of people are nervous the first time they come along to a star party,” says Wilkins.

“Especially if you come alone, there is a fear you could be isolated.” However, in practice that's really not how star parties work. “Don't feel intimidated about going to your first star party, even if you're alone, because astronomers are a really friendly bunch of people who are really passionate,” says Wilkins. “A star party is the best way to immerse yourself in astronomy.” 🌌

Where to star party in 2019

Here are some of the major stargazing events across the UK and Ireland this year. Always check with organisers to confirm dates before planning your trip



ENGLAND

1 Kielder Forest Star Camp

Kielder Campsite, Kielder Forest Star Camp, Hexham
6–11 March & 30 October–4 November
www.sunderlandastro.com/star-camp

2 Spring Star Party/ WinterFest Astro Star Party

Kelling Heath, Holt, Norfolk
1–8 April & November (tbc)
www.starparty.org
www.winterfestastro.co.uk

3 Dalby Forest StarFest

Adderstone Field, Dalby Forest, North Yorkshire
29 August–2 September
www.scarborough-ryedale-as.org.uk/saras/starfest/starfest-2019

4 Stargazers Lounge Star Party

Lucksall Camping and Caravan Park, Hereford
Autumn (tbc)
sglsp.com

SCOTLAND

5 Galloway Gathering

Drumroamin Farm Camping & Caravan Site, Newton Stewart
27 February–4 March & 30 October–4 November
www.drumroamin.co.uk

WALES

6 Astrocamp

Cwmdu Caravan & Camp, Brecon Beacons Dark Sky Reserve

27–30 April & 21–24 September

www.astrocamp.awesomeastronomy.com

7 Solarsphere Astronomical and Music Festival

Penmaenau Farm, Builth Wells
9–12 August
www.solarsphere.events

IRELAND

8 Skellig Star Party

Kerry Dark Sky Reserve, Ballinskelligs, Co Kerry
24–25 August
www.skelligstarparty.com

9 Mayo Dark Sky Festival

Mayo Dark Sky Park, Newport, Co Mayo
November (tbc)
www.mayodarkskyfestival.ie

Image courtesy of Stefan Muckenhuber
taken with an Atik 460EX

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See our website for more details, invaluable advice, tips and tricks, and of course... incredible images.

Few images are more
captivating than a rising
full Moon in all its glory



Photograph the rising FULL MOON

The rising full Moon can be one of the most breathtaking sights in all of astronomy. **Will Gater** offers his expert guide on how to shoot the spectacle



A resplendent deep-orange Harvest Moon makes a superb subject for September

Whether you live on a bustling city street or in a remote rural area, on flat terrain or surrounded by towering mountains, the rise of a full Moon rarely fails to make an impression. Maybe it's the element of the mystical that draws us to the sight – a fascination forged from millennia of watching our satellite's dance across the night sky, combined with the strange little trick our brain plays on us by making the lunar disc appear larger when it's near the horizon. Whatever the reasons, this common event seems to be endlessly captivating.

For astrophotographers, the allure of a full moonrise has something of a dark side, not least because it requires overcoming technical, meteorological and planning issues while somehow



Will Gater is an astronomy writer and presenter. Follow him on Twitter at @willgater or visit willgater.com

Our photogenic atmosphere

Visual effects created by Earth's atmosphere can add impact to your shots of the full Moon

There are several phenomena that can appear at moonrise that are just as rewarding to capture as the lunar disc itself, and including these in your photographs will really enhance them.

Perhaps the best example is the beautiful, but transitory, **Belt of Venus**. This manifests itself as a pinkish swathe of sky low across the eastern horizon after sunset. It's

caused by the rich reddened colours of the sunset scattering back at us off the atmosphere. Below it you'll also see a dark, grey-blue band, which is Earth's shadow cast onto the sky.

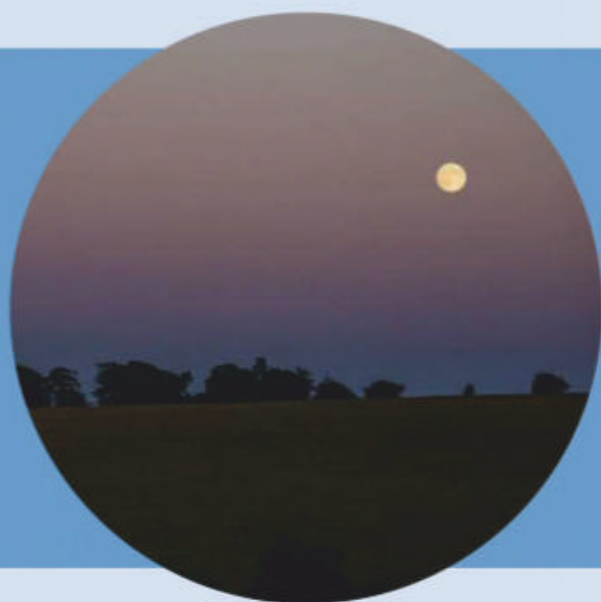
Since both phenomena are seen in the eastern sky in the evening, it is common to see the yellowy disc of the full Moon rising through these colourful layers – something

that can make for a really striking picture.

If you have a long focal length lens or telescope, and are imaging the moonrise up close, you may also be able to capture two other interesting optical effects. When the full Moon is very low, refraction by Earth's atmosphere gives the upper limb of the lunar disc a **blueish green edge** and the lower limb a deep red rim.

Occasionally, if the atmospheric conditions along your line of sight to the Moon are just right, the upper greenish edge can sometimes be distorted by a mirage effect to produce a **lunar green flash**. This rare occurrence appears as a fleeting green patch of light above the – typically rippling and undulating – upper limb of the lunar disc.

ALL PICTURES: WILL GATER



▲ Look east to capture the subtle pinkish glow of the Belt of Venus after sunset



▲ A close-up can reveal a red rim to the lower edge of a very low Moon



▲ Photographing the shimmering lunar green flash on the upper rim is challenging

Snap a seemingly massive Moon

Using the effects of perspective distortion, you'll capture a fantastic image

If you've browsed space photos on social media, you will no doubt have seen images where the rising full Moon looks enormous against the foreground. Many are works created by digital artists, while others are artificial composites. Some, though, are genuine single-shot exposures of an apparently huge lunar disc looming over a horizon – perhaps a distant treeline, a city skyline or people on a hilltop in silhouette, like on this issue's cover. How do astrophotographers capture these moonrise images?

Two things are needed. The first is that the photos are almost always created using a **long focal length telescope**, at least compared to most camera lenses. For a full-frame format DSLR this might mean a scope around 1,000–1,300mm in focal length, while an APS-C sensor DSLR might only need a focal length of 600–800mm. Shorter focal length scopes can still produce a similar effect but it won't be as dramatic



▲ To capture a huge Moon, combine a DSLR with a scope of at least 600mm

– unless you can crop the image – as the Moon's disc will be smaller compared to the amount of earthly surroundings shown elsewhere in the frame.

The second factor is that you must **image the foreground from a distance** – not just a few tens of metres but a kilometre away, sometimes more. This means the foreground and the rising lunar disc will be seemingly in the same plane.

With the tight field of view provided by the long focal length scope and no depth cues to signal that the foreground is far from the camera, you get perspective distortion and an apparently giant Moon rising materialises. These images need careful planning and still, transparent skies close to the horizon to work well. But if you can pull it off, the effort of setting up a telescope just for that brief moment of moonrise will often be rewarded by an absolutely spectacular final image.

still managing to convey the magic of the moment.

The first task for shooting this event is to work out both when and where the full Moon will rise. If you've not paid much attention to this element of celestial mechanics before, you might not know that the full Moon rises in different places along the eastern horizon at different times of the year; its azimuth at the moment it breaks the horizon varies greatly. So

“What makes or breaks a great full moonrise shot is the quality of your planning”

before we even pack our camera bag we need to have a good idea of where to expect the lunar disc and what local topography will allow us to glimpse it there. What makes or breaks a great full Moon rise photograph is

the quality of your planning. Thankfully there are many excellent resources that make this stage of imaging a breeze.

Pick your spot

The first place to start will be a decent planetarium programme like Stellarium (stellarium.org) or SkySafari (available for smartphones/tablets). With these you can find out the azimuthal position and ►



A reddened Moon rises through the Belt of Venus as seen from Somerset, UK

► timing of the full Moon rise for a given day. And if you aren't sure what day full Moon is, consult the Sky Guide in your copy of this magazine. Once you have this information you can then think of a suitable – and visually interesting – imaging location where you will have a good view of this part of the horizon.

All sorts of landscapes can make for great full Moon rise pictures, from brightly-lit urban areas to tree-covered hills, even open expanses and distant sea horizons. Often the most powerful compositions include viewpoints with horizons many kilometres away, where the features on the skyline are shot with a longer focal length lens or telescope so as to appear small under the large Moon rising above.

To find the perfect perspective for your shot, you may need to explore a few locations in daylight, far in advance of when you actually intend to image the moonrise. Apps like the Photographer's Ephemeris and PhotoPills can help here, as they can show you the direction that the Moon will rise, overlaid on a



Check out your imaging site in advance, using a compass to pinpoint where the Moon will be



Build composite images to catch both the Moon and the foreground at their best



A lunar balancing act

Finding harmony between the foreground and background can be the key to a great lunar image

Cloud or haze can obscure the full Moon when it first rises so that, by the time it appears, your foreground has been plunged into darkness. This makes it difficult to expose both the shining lunar disc and the unlit landscape correctly in a single shot. Sometimes you

can overcome this problem by taking several images with a range of exposure lengths that capture the Moon and landscape separately, then combining them in image-editing software.

Tread carefully, however, as this technique can sometimes produce jarringly

artificial results. At a minimum you will need to capture two exposures – one for the foreground and another for the Moon. Avoid the temptation to expose the lunar disc perfectly. Aim for it to be quite a bit brighter than you would normally have it, as this will make for

a more natural-looking composite; otherwise, when you copy and paste the disc into the correctly-exposed landscape shot in your chosen image editor, you can sometimes end up with a darker full Moon within a bright, glowing halo, which can look rather odd.

satellite map. If you do make a site visit, take an accurate compass with you to check that you will definitely have a clear line of sight towards where you expect the lunar disc to appear.

Plan your shot

One really important point that's worth noting is that the timing of moonrise shown in a planetarium programme or in a published almanac won't necessarily always match up with the actual moment that you'll first spot the Moon on the night. This has major implications for composing certain types of full Moon rise shot.

For example, if there's thin haze or cloud on the eastern horizon, it might be 10–15 minutes after the published rise time that the lunar disc clears this layer and becomes visible. What's more, by the time it does appear it will have moved considerably from its 'on-paper' rising azimuth. If you're using a long focal length lens or telescope and are intending to frame the Moon with a faraway feature – like a gap in the trees or a far away hilltop – this shift could end up ruining your shot. It might be worth having a plan-B composition in case the Moon doesn't appear exactly where you planned it.

In a similar vein, the size of the field of view of your imaging setup will constrain how long you've actually

got to snap the lunar disc over a landscape. For example, the field of view of my preferred moonrise imaging kit – an APS-C sensor DSLR and a 388mm focal length refractor, in portrait orientation – is about 3° in height. This means that if I'm shooting a low horizon line and wish to include a decent amount of landscape in the shot, I have until the full Moon gets to an altitude of around 2.5° before the lunar disc starts to get too high and the composition starts to look unbalanced. You can use Stellarium's field-of-view plugin with your own kit specifications, and a simulation of the full Moon rising, to work out roughly how much leeway you have with your setup.

There's one final time constraint you will also want to consider. As the twilight sky darkens, the level of foreground illumination lowers. At the same time, the rising lunar disc becomes more visible against the dimming sky. This means that there's only a short period of time just after moonrise when the brightness difference between the lunar disc and the twilight-lit foreground is small enough to capture both well in a single shot; wait too long and the 'dynamic range' of the scene will be too great and you won't be able to correctly expose both the shining disc and the landscape in the same image.

For wide-field images this can sometimes be overcome with a composite shot – taking several ►

▼ The atmosphere can distort the Moon dramatically and make it appear deep orange or reddish



This image of the full Moon rising over Toronto is taken when the foreground and lunar disc are equally well illuminated



► pictures, then combining them in image-editing software – but such techniques have to be done with care as they can look very unnatural if crudely executed. In my opinion, some of the most successful full Moon rise shots are those where the lunar disc and foreground are recorded in one exposure. If you agree, you will want to make sure that you are in position at your imaging site in good time to take advantage of the narrow window where the light levels are balanced after the Moon breaks the horizon.

But even if your timing or planning is a little out – or the weather conditions don't cooperate to present the exact composition you were after – don't be put off. Next month will always, without fail, bring with it the chance to try it all over again. 🌕

Insight Investment Astronomy Photographer of the Year

Mastered the techniques in this feature and taken a stunning photo of the rising full Moon? This year's competition is now open for entries. See page 60 for details.

ISTOCK, WILL GATER

Red Moon rising

The ever-changing face of the Moon never fails to fascinate, and the fading colour of a rising lunar disc can make a great photo

As the full Moon peeks over the horizon its disc takes on a yellowy or sometimes deep red and even coppery colour. This is because our atmosphere scatters bluer wavelengths of light more effectively than redder ones; essentially the bluer hues within the moonlight are filtered out and what reaches our eyes and cameras are the redder remnants. As the lunar disc gains altitude, however, the slice of

atmosphere the moonlight has to travel through to reach us gets shorter in length. The level of filtering diminishes because of this and so, as it rises, the Moon slowly regains its familiar silvery-white colour. This transition can make for striking astro images. Wide-field composites, showing the lunar disc moving across the frame, can be particularly effective. These can be



A landmark like a hill, building or treeline can draw the viewer's eye into your Moon picture

created in much the same way as a 'startrail' shot, with many exposures – including

a fixed landscape or horizon – being combined in image-editing software.



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Students aged 14-18 can meet and work with Astronauts Michael Foale (left) and Tony Antonelli (right) for a week at Mission Discovery, hosted at King's College London **8th - 12th July 2019** and compete to launch an experiment they design into space to be carried out by astronauts aboard the International Space Station!

“It was simply brilliant and I will recommend it to many others! I learned so much but it didn't feel like school.”

- Joanna, Mission Discovery 2018 participant

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The Sky Guide

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THE TOP SIGHTS BETWEEN
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FEBRUARY'S FULL MOON IS
2019's BIGGEST & BRIGHTEST

PETE LAWRENCE

About the writers



Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Stephen Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Red light friendly



To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Don't miss...

- ◆ Fading comet 46P/Wirtanen in Ursa Major
- ◆ Several well-placed lunar clair obscur effects are on view
- ◆ A line-up of the Moon, Venus, Jupiter and Saturn

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky, sign up to our newsletter: www.skyatnightmagazine.com/iframe/newsletter-signup

FEBRUARY HIGHLIGHTS

Your guide to the night sky this month

Friday
1 📷 A morning trio will greet early risers with an 11%-lit, waning crescent Moon, mag. -4.1 Venus and mag. -1.7 Jupiter being visible low in the southeast from around 06:15 UT. Saturn should be visible as well shortly after 07:00 UT.



◀ **Saturday**
2 📷 This morning the now 5%-lit, waning crescent Moon sits very close to the mag. +0.9 planet Saturn. From certain parts of the UK the Moon will rise in front of Saturn, the planet reappearing soon after moonrise. Turn to page 46 for further information.

Monday
4 📷 Comet 46P/Wirtanen remains in Ursa Major all month, potentially remaining a binocular object for the first half of February. By the end of the month it's expected to have faded to mag. +10.1. Turn to page 53 for more information.

Tuesday ▶
5 📷 This morning mag. -4.1 Venus lies 2° north of the Trifid Nebula, M20.

📷 Mag. +1.3 Mercury appears 3.6° from a less than 1%-lit, waxing crescent Moon in this evening's sky.



Sunday ▶
10 📷 Venus appears 2° south of open cluster M25 this morning.

📷 The Moon shows the clair obscur effect Alexander's Beaded Rim – dots of light around the western rim of 82km crater Alexander, which should

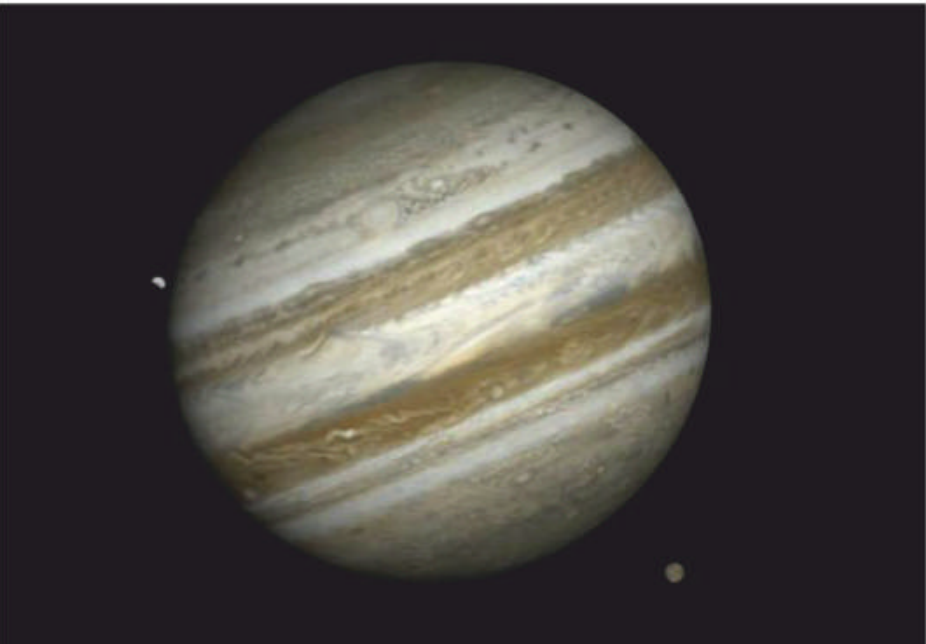


Monday
18 📷 This morning, mag. -4.0 Venus sits 1.1° north of mag. +1.0 Saturn, with Venus 6.2 arcminutes north of mag. +2.9 Albaldah (Pi (π) Sagittarii).

📷 This and tomorrow evening Mercury will appear about 1° from Neptune.

Tuesday
19 📷 Venus, Saturn and Albaldah (Pi (π) Sagittarii) make an attractive triangle in the morning sky

📷 Today's full Moon will be the closest for 2019. Turn to page 47 for further details.



◀ **Saturday**
23 📷 Jupiter's outer Galilean satellite Callisto sits just to the north of Jupiter's disc this morning.

Wednesday
27 Mercury reaches greatest eastern elongation today when it's separated from the Sun by 18.1°.

NEED TO KNOW


The terms and symbols used in The Sky Guide


Universal time (UT) and British Summer Time (BST)


Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.


RA (Right ascension) and dec. (declination)


These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'.


 **Family friendly**
Objects marked with this icon are perfect for showing to children

 **Naked eye**
Allow 20 minutes for your eyes to become dark-adapted

 **Photo opp**
Use a CCD, planetary camera or standard DSLR

 **Binoculars**
10x50 recommended

 **Small/medium scope**
Reflector/SCT under 6 inches, refractor under 4 inches


 **Large scope**
Reflector/SCT over 6 inches, refractor over 4 inches




GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing a scope.


Sunday ►

3  A telescopic view of Jupiter this morning will show the Jovian moon Ganymede's giant shadow centrally on the planet's disc around 05:30 UT.


Wednesday

6  Minor planet 532 Herculina reaches opposition at mag. +8.9 in Leo.


Tuesday

12  Mars and Uranus are close this evening with a minimum separation of 1°.

Friday

22  As midnight approaches, the clair obscur effect known as the Twin Spires of Messier will be visible. This appears as a curious, double-peaked shadow attached to the rim of crater Messier.

Thursday

28  A 32%-lit, waning crescent Moon lies 7.6° to the east of Jupiter this morning. Saturn is in the vicinity too.


Thursday

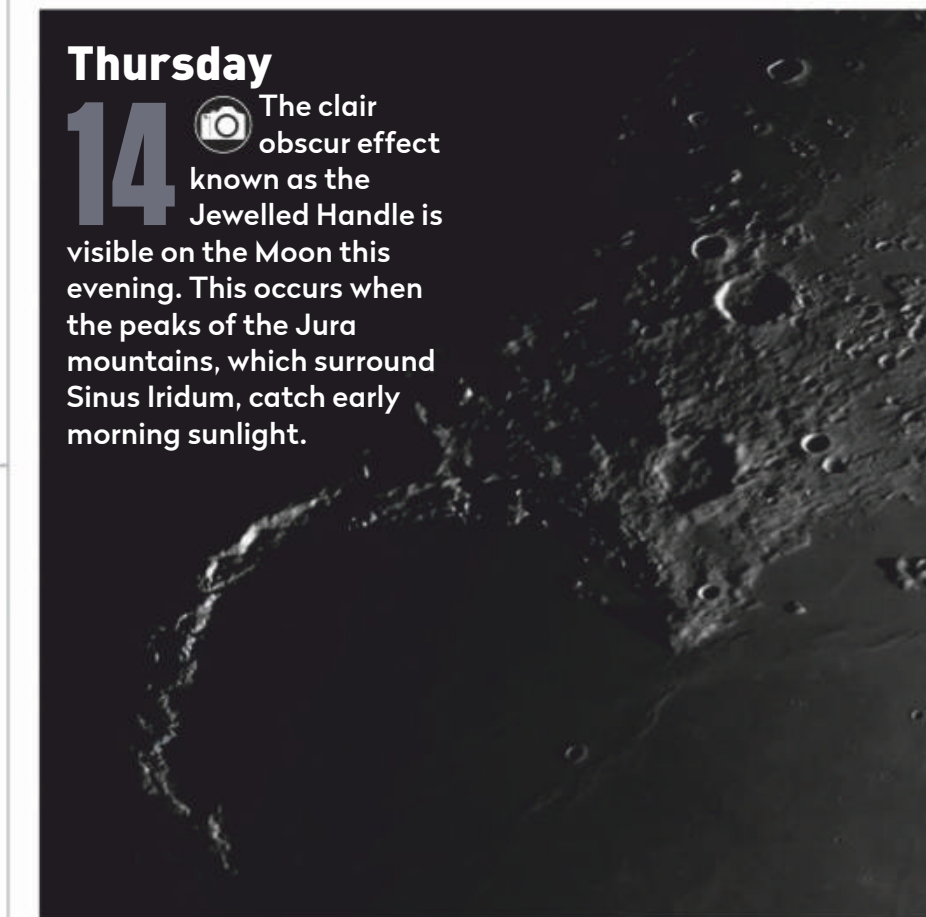
7 Brilliant Venus appears just 19.5 arcminutes from mag. +3.8 Mu (μ) Sagittarii this morning.

Saturday


9 This month's Moonwatch target, the crater Littrow, is on the Moon's terminator this evening.

Thursday

14  The clair obscur effect known as the Jewelled Handle is visible on the Moon this evening. This occurs when the peaks of the Jura mountains, which surround Sinus Iridum, catch early morning sunlight.



Family stargazing – Moon shadows

 Clair obscur effects (strange shadows that only appear at certain times) add excitement to lunar observations, especially for young observers. There are three prominent ones this month (see 10, 14 and 22 February above), which should all be easy to spot through a telescope. Alexander's Beaded Rim looks like an arc of stars, and is caused by peaks along the edge of crater Alexander. A similar condition produces the Jewelled handle. The Twin Spires of Messier is odd, though: two spiked shadows that don't seem to match what creates them. www.bbc.co.uk/cbeebies/shows/stargazing

THE BIG THREE

The three top sights to observe or image this month



Looking just to the north (left) of southeast at 06:44 UT on 2 Feb through 7x50 binoculars



From southeast parts of the UK you'll be able to see Saturn emerge from behind the Moon at 06:30 UT on 2 February

binoculars trained toward a flat southeast horizon should be able to spot them. From the centre of the UK at 07:00 UT, around one hour before sunrise, both objects appear separated (centre-to-centre) by 27 arcminutes, Saturn appearing just 12 arcminutes from the Moon's dark limb.

The Moon's apparent position against the background stars and planets shifts when viewed from different locations due to parallax. So observing the pair from a location further south and east, the Moon will hide Saturn in a rare occultation event.


This will not be an easy thing to see because of the brightening sky and low altitude. Occultation disappearance occurs when the Moon is below the horizon, but from certain parts of the country, reappearance will be visible with Saturn emerging from behind the Moon's dark limb just after 06:30 UT.

If you try for this, it's essential to pick the Moon up as soon as possible after it rises. A really clear sky is essential as any atmospheric haze will tend to make the Moon harder to see. With only a short time between rise and reappearance, this is an exciting observing challenge.

DON'T MISS

Saturn and THE MOON

BEST TIME TO SEE: 2 February from 06:20 UT – Moon may rise later than this from northwest locations

 The paths of the Moon and main planets stay relatively close to the ecliptic. This great circle represents the apparent path of the Sun against the background stars throughout the course of a year, revealing the orbital plane of the Earth around the Sun. The main outer planets have similar inclinations, which is the reason why they appear to stay close to the ecliptic. Venus's inclination is larger at 3.4° with Mercury having the largest value of 7°. Our Moon's orbit is inclined to the ecliptic by 5.1°.

Consequently the Moon has the ability to occult any of the main planets over time. In reality, though, such occultations are rare because the Moon's apparent size is relatively small at around 0.5° and its monthly circuit of the sky tends to see it pass above or below each planet.

Although occultations are rare, each month the Moon appears close to each of the main planets, an event known as a conjunction. Technically there are different definitions of 'conjunction', the most common defining two bodies with the

same ecliptic longitude. In general use, however, the term tends to be used to describe two bodies close enough to appear impressive to the naked eye.

Saturn and a 5%-lit, waning crescent Moon will present themselves in this way on 2 February. Both objects rise around 06:50 UT as seen from the centre of the UK, so they will appear very close to one another. The pairing will be tricky to see thanks to the onset of dawn but

Occultation reappearance occurs at low altitude over a flat southeast horizon. At the edge of the occultation zone, altitude is less than 1°. From Dover, the altitude is 2.5°



Morning planets

BEST TIME TO SEE: 1–2, 18 and 28 February

As well as the lunar conjunction and the location-dependent occultation of Saturn on 2 February, there are a number of other interesting things going on in the morning sky throughout February.

On the first day of the month, mag. -1.7 Jupiter sits 9.3° west of mag. -4.1 Venus. Meanwhile, an 11%-lit, waning crescent Moon will sit 6.2° east of Venus on this date. If the sky is clear, this will be a beautiful sight to behold from around 06:00 UT.

The next morning the Moon will have moved further east for its encounter with Saturn as described on the opposite page, leaving Jupiter and Venus as paired light beacons before the onset of dawn.

Venus will be moving slowly east against the background stars during February. This movement takes it into the northern reaches of Sagittarius.

On the morning of 5 February, brilliant Venus lies 2° to the north of the Trifid Nebula, M20, an interesting and unusual sight and a great target for astrophotography. On 7 February, Venus will sit 19.5 arcminutes from mag. $+3.8$ Mu (μ) Sagittarii and on 10 February the planet will have moved to lie 2° south of open cluster M25.

On 18 February, mag. -4.0 Venus will have caught up with Saturn, appearing 1.1° north of the ringed planet on this date. On 19 February, Venus, Saturn and mag. $+2.9$ Albaldah (Pi (π) Sagittarii), make an attractive pre-dawn triangle.

Finally, as we head towards the end of the month, the Moon once again makes its presence known. On 28 February, a 32%-lit, waning crescent Moon lies 7.6° to the east of Jupiter in the pre-dawn sky. Saturn will appear too, shortly after 05:00 UT with



▲ The Moon and planets put on some impressive displays in February

Venus marking the end of the planetary line approximately 30 minutes later. At 06:00 UT

all four Solar System objects will form a stunning line-up low in the southeast.

2019's perigee full Moon

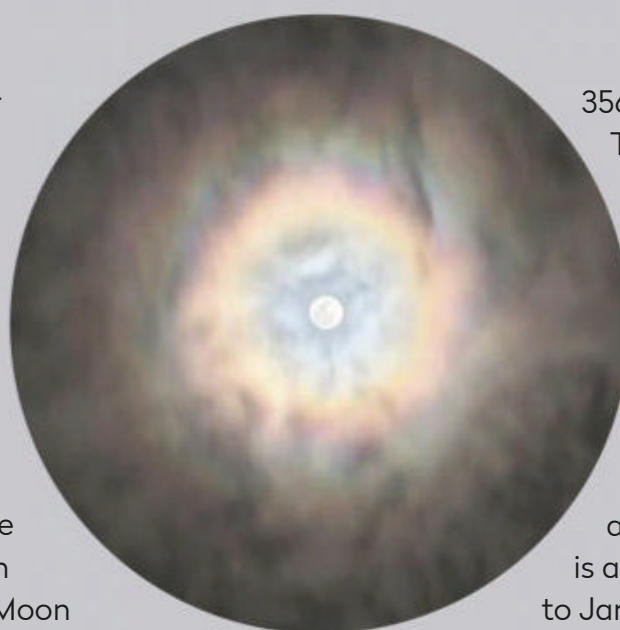
BEST TIME TO SEE: 19 February

The Moon's orbit is elliptical which means that our nearest neighbour's distance from us varies over the course of a full circuit. When it's at its closest to Earth, a point in its orbit known as perigee, its average distance is 362,600km. At the furthest point, known as apogee, its average distance is 405,400km. The phase of the Moon that occurs at these points varies over time. Consequently, a particular phase may occur near perigee one month but move away from it in subsequent months.

This behaviour means that there tend to be a number of months when, for example, full Moon occurs closer to

perigee than at other times for a particular year. The closest full Moon to perigee presents the largest apparent size and brightness for the year. The popular term for this is a 'supermoon'.

This month, perigee occurs at 09:07 UT on 19 February with full Moon being reached at 15:53 UT on the same date. The Moon's distance will be



▲ On 19 February the Moon will be both full and at perigee, its closest point to Earth

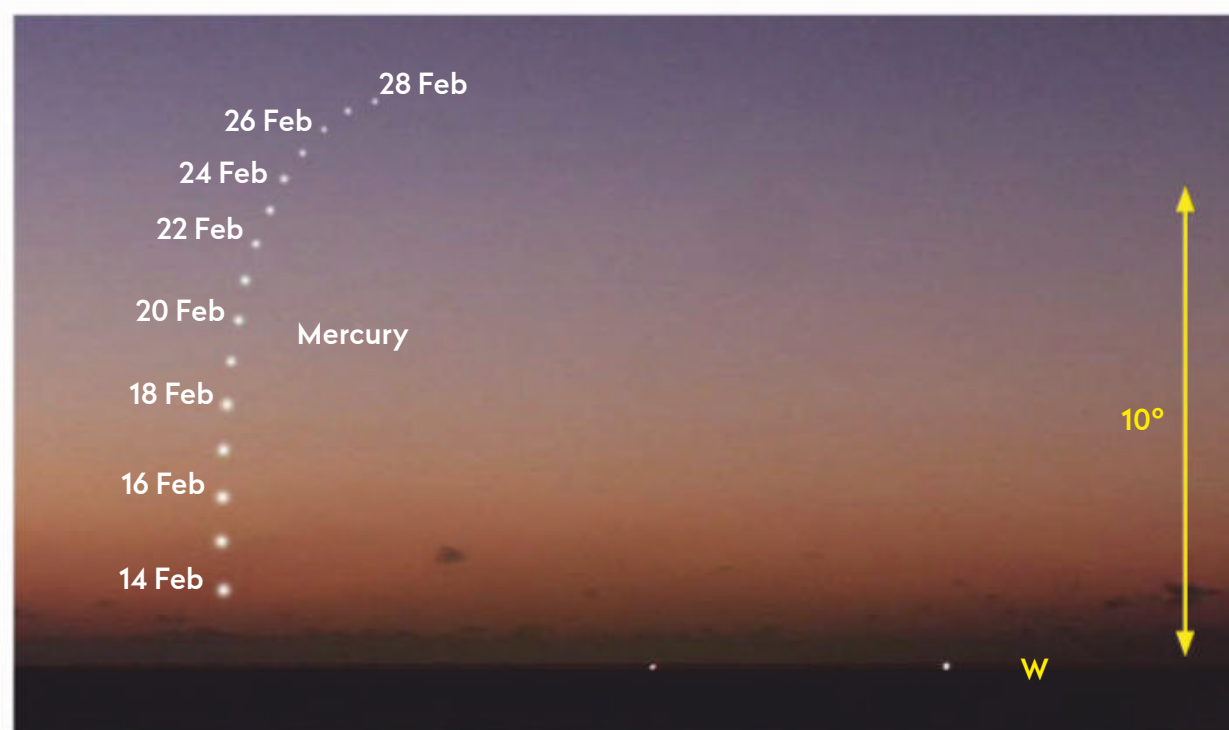
356,761km at this time.

This close occurrence of perigee and the full phase makes this month's full Moon the perigee full Moon of 2019.

The difference in apparent size between a perigee and apogee full Moon is around 14%. Compared to January's full Moon which also occurred close to perigee, the difference will be miniscule.

THE PLANETS

Our celestial neighbourhood in February



▲ Mercury climbs quite steeply in the sky throughout the month of February

PICK OF THE MONTH

Mercury

Best time to see: 27 February, 45 minutes after sunset

Altitude: 9°

Location: Pisces

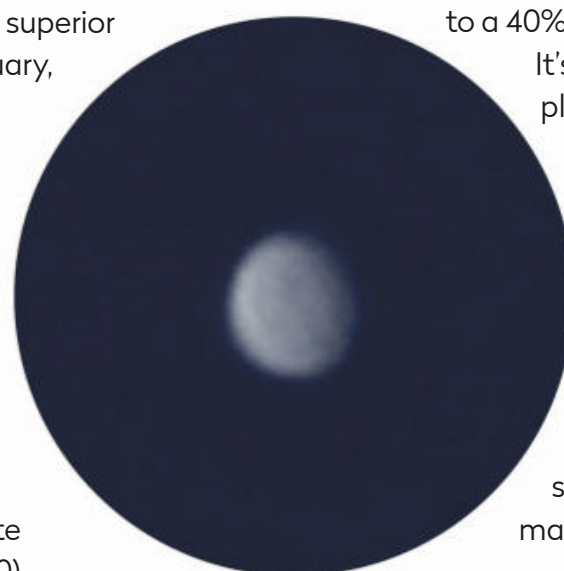
Direction: West

Features: Phase, surface shading with larger instruments

Recommended equipment: 3-inch telescope or larger

In February Mercury is an evening object but, having just passed superior conjunction on 30 January, is too close to the Sun to be seen at the start of the month. It will probably grow visible in the middle of the month, aided by the steep angle the ecliptic makes relative to the west-southwest horizon at sunset, and because Mercury is quite bright (around mag. -1.0) at this time.

On 14 February Mercury sets roughly



▲ Mercury will be especially bright mid-February at mag. -1.0 , though low on the horizon as ever

one hour after the Sun. Greatest eastern elongation, when Mercury appears 18.1° from the Sun in the evening sky, occurs on 27 February. Mercury will be mag. -0.2 and set 100 minutes after the Sun on this date.

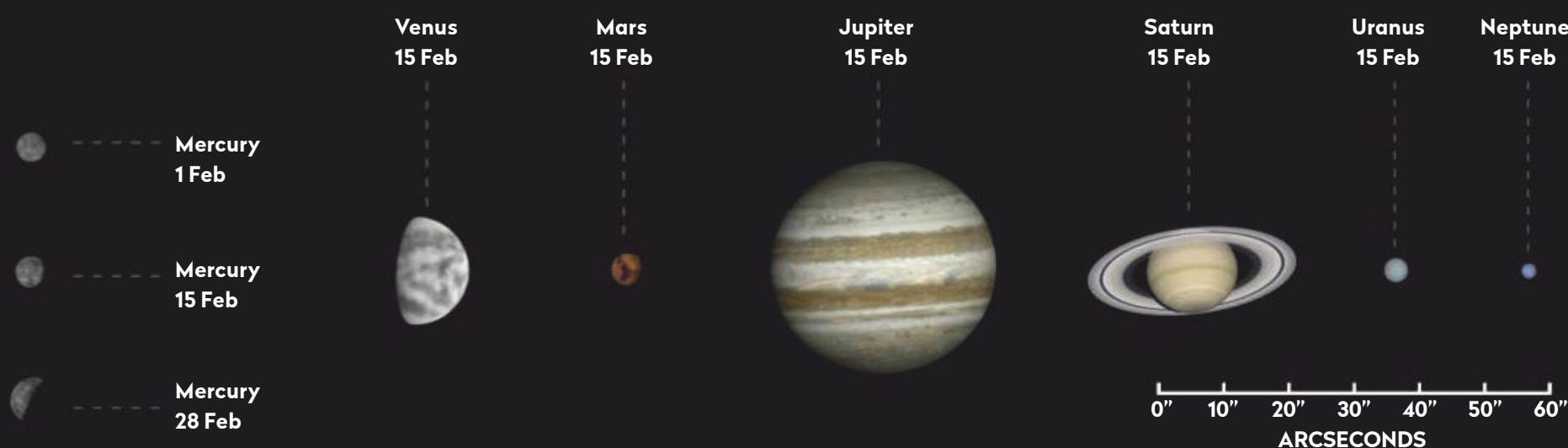
Telescopically, Mercury will appear in gibbous phase mid-month. On 16 February it shines at mag. -1.1 and displays an 85%-lit disc, 5 arcseconds across. By 24 February, its increased separation from the Sun will make it easier to see after sunset, despite its magnitude dipping to mag. -0.6 . Through the eyepiece on this date the planet will have grown in apparent size to 6 arcseconds and show a 58% phase.

By the end of February, Mercury will be very well placed, counteracted slightly by a continued dimming to mag. -0.1 . The eyepiece changes continue in the same direction with the apparent size increasing to 7 arcseconds and the phase dropping to a 40%-lit crescent.

It's not the easiest of planets to view through a telescope as its typically low altitude after sunset makes it easy to lose behind foreground objects. However, if you can get a view of it and the atmosphere is steady enough, you may be able to make out subtle variations in the brightness of its rocky surface at high magnification.

The planets in February

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Venus

Best time to see: 18 February, from 06:00 UT

Altitude: 3° (very low)

Location: Sagittarius

Direction: Southeast

On 1 February look southeast around 06:30 UT for mag. -1.7 Jupiter, mag. -4.1 Venus and an 11%-lit, waning crescent Moon. On the mornings of 4-6 February, Venus appears close to M8 and M20 in Sagittarius – an unusual astrophotographic opportunity (see page 46). At the end of the month, mag. -4.0 Venus, now 15 arcseconds across and 71% lit, rises 90 minutes before the Sun.

Mars

Best time to see: 1 February, 18:45 UT

Altitude: 39°

Location: Pisces

Direction: Southwest

Evening object Mars begins the month in Pisces, 3.7° east of mag. +4.3 Epsilon (ε) Piscium, at mag. +0.9, with a 6 arcsecond, 89%-lit disc. A 28%-lit, waxing Moon lies 6.4° south of Mars on 10 February. On 13 February Mars will be in Aries where it remains for the month, ending February at mag. +1.2 with a 5 arcsecond disc.

Jupiter

Best time to see: 28 February, from 05:00 UT

Altitude: 10°

Location: Ophiuchus

Direction: South-southeast

On 1 February, around 06:30 UT, mag. -1.7 Jupiter sits 9.4° west of mag. -4.1 Venus. A 10%-lit Moon sits 6.7° east of Venus at the same time. Jupiter edges east through the month, ending up on the eastern knee of Ophiuchus on 28 February.

Saturn

Best time to see: 28 February, 05:40 UT

Altitude: 4° (very low)

Location: Sagittarius

Direction: Southeast

Mag. +0.9 Saturn is visible low in the southeast in the morning twilight. On 1 February it appears with mag. -4.1 Venus, mag -1.7 Jupiter and an 11%-lit, waning crescent Moon. The following morning a 5%-lit Moon and Saturn appear so close that some locations will see the planet emerge from lunar occultation. On 18 February Saturn and Venus appear just over 1° apart. Early on 28 February, Saturn is part of a line-up with Jupiter, a 32%-lit Moon and Venus.

Uranus

Best time to see: 10 February, 19:00 UT

Altitude: 39°

Location: Pisces

Direction: Southwest

Uranus becomes visible in the southwest as darkness falls. Mag. +1.9 Mars and a 28%-lit, waxing crescent Moon join the scene on 10 February, with Mars 1.9° from Uranus. By the end of the month Uranus will have lost a lot of altitude, appearing 25° up as the sky begins to darken.

Neptune

Best time to see: 1 February, 18:45 UT

Altitude: 10°

Location: Aquarius

Direction: West-southwest

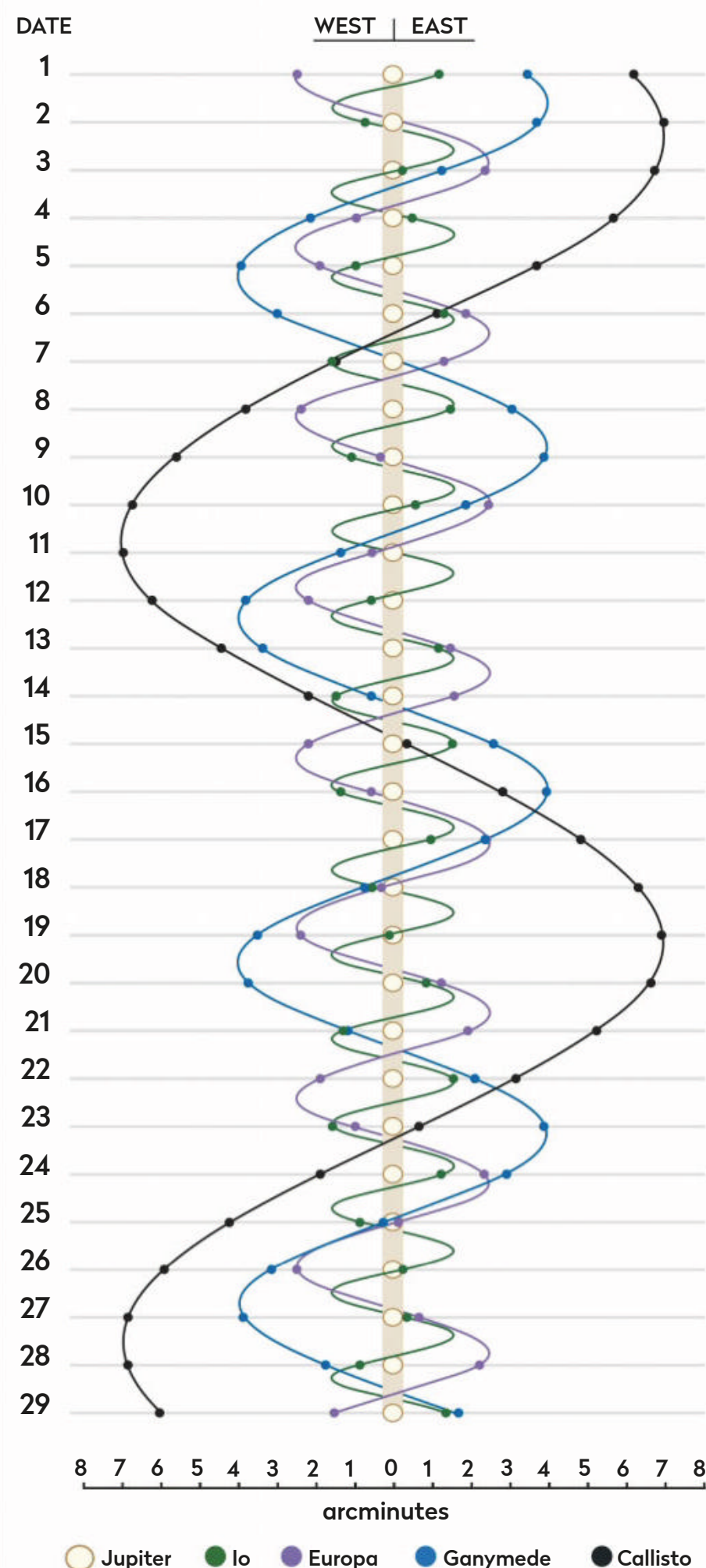
Neptune is too low for serious observation this month, the mag. +7.9 planet being low in the west-southwest as darkness falls at the start of the month. On 18 and 19 February, mag. -1.0 Mercury appears around 1° from mag. +8.0 Neptune. Neptune may have slipped too far into the evening twilight to be seen at this time, but photographs should reveal it.

More **ONLINE**

Print out observing forms for recording planetary events

JUPITER'S MOONS FEBRUARY

Using a small scope you'll be able to spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – FEBRUARY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

Arcturus STAR NAME

PERSEUS CONSTELLATION NAME

GALAXY

OPEN CLUSTER

GLOBULAR CLUSTER

PLANETARY NEBULA

DIFFUSE NEBULOSITY

DOUBLE STAR

VARIABLE STAR

THE MOON, SHOWING PHASE

COMET TRACK

ASTEROID TRACK

STAR-HOPPING PATH

METEOR RADIANT

ASTERISM

PLANET

QUASAR

STAR BRIGHTNESS:

MAG. 0 & BRIGHTER

MAG. +1

MAG. +2

MAG. +3

MAG. +4 & FAINTER

COMPASS AND FIELD OF VIEW

MILKY WAY

When to use this chart

1 February at 00:00 UT

15 February at 23:00 UT

28 February at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in February*



Date	Sunrise	Sunset
1 Feb 2019	07:56 UT	16:52 UT
11 Feb 2019	07:37 UT	17:12 UT
21 Feb 2019	07:17 UT	17:32 UT
03 Mar 2019	06:54 UT	17:51 UT

Moonrise in February*

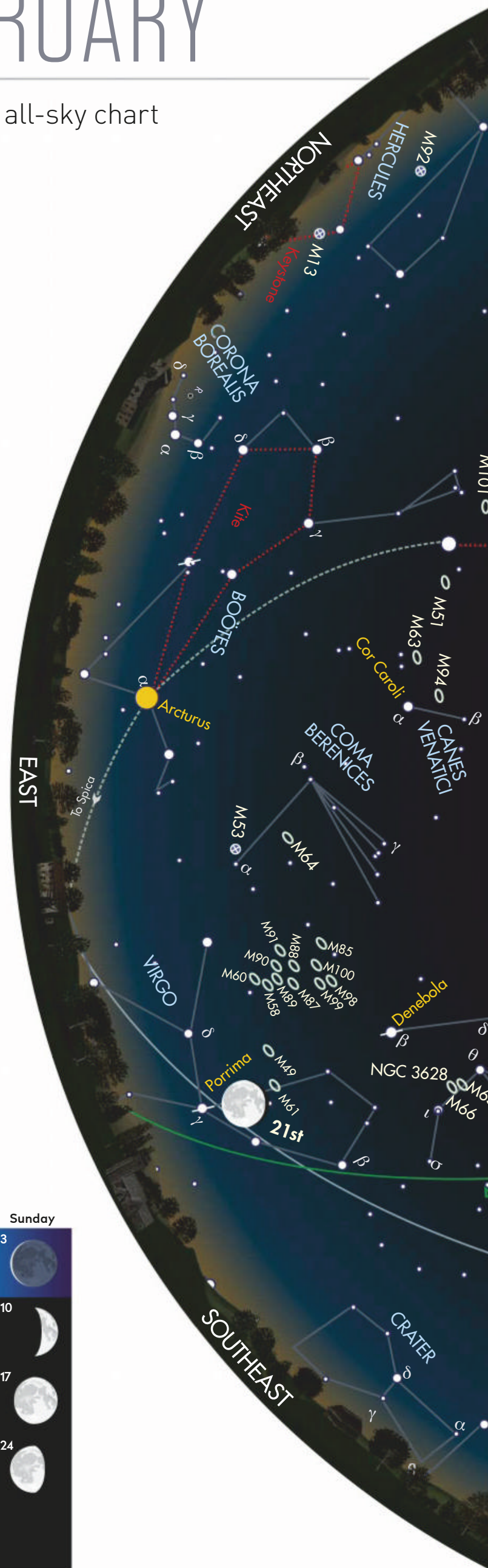


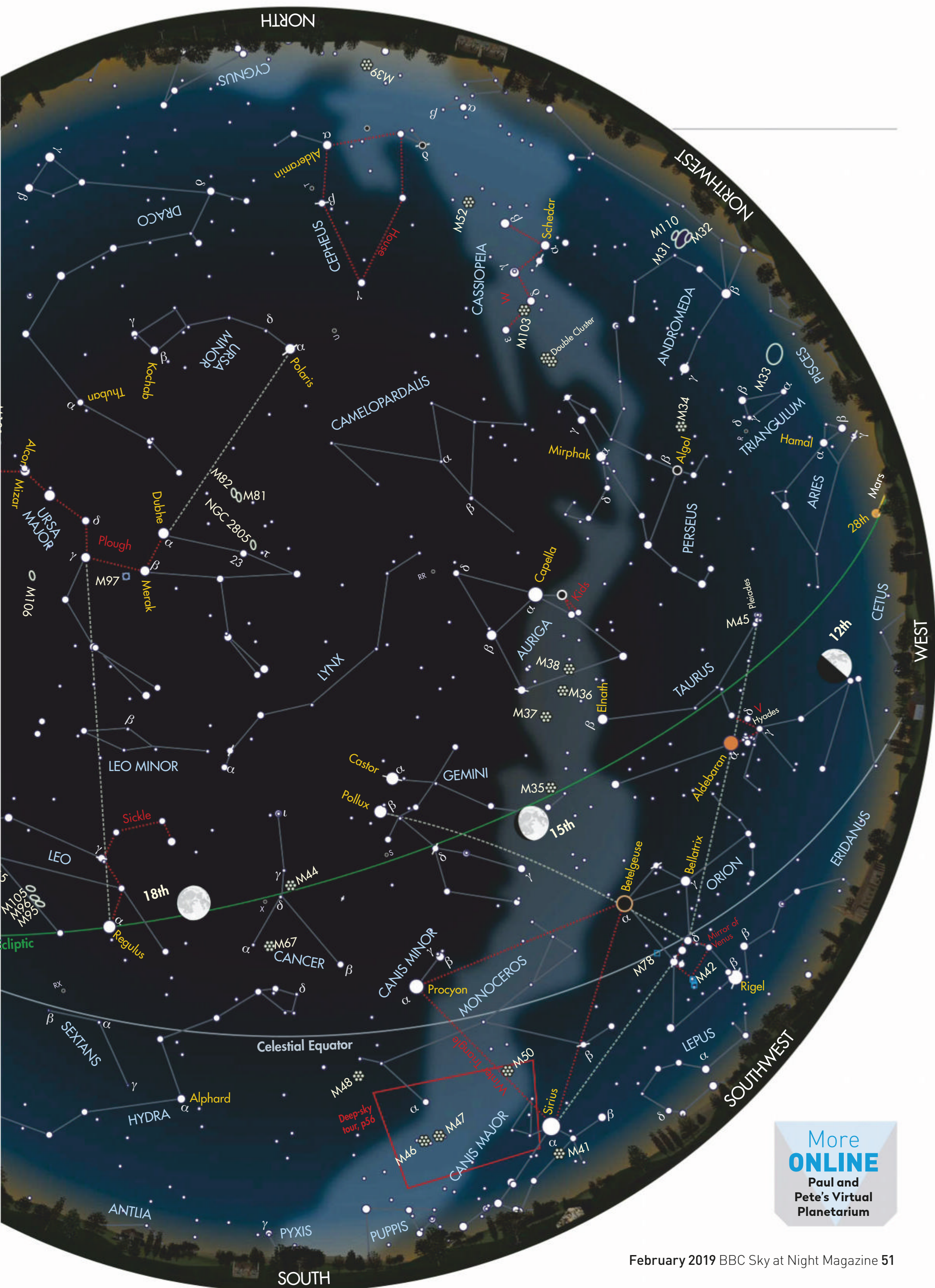
Moonrise times	
1 Feb 2019, 05:43 UT	17 Feb 2019, 14:27 UT
5 Feb 2019, 08:22 UT	21 Feb 2019, 20:10 UT
9 Feb 2019, 09:41 UT	25 Feb 2019, 00:13 UT
13 Feb 2019, 11:05 UT	01 Mar 2019, 04:33 UT

*Times correct for the centre of the UK

Lunar phases in February

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			





More
ONLINE
Paul and
Pete's Virtual
Planetarium

MOONWATCH

February's top lunar feature to observe

Littrow

Type: Crater

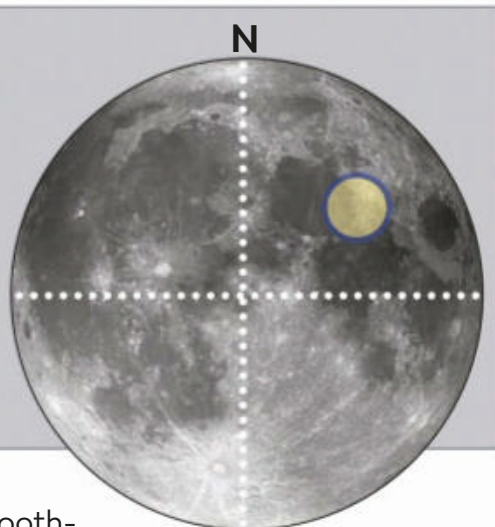
Diameter: 31km

Longitude/latitude: 31.4° E, 21.5° N

Age: Older than 3.8 billion years

Best time to see: Five days after new Moon (9–10 Feb) and four days after full Moon (23–24 Feb)

Minimum equipment: 2-inch refractor



Crater Littrow is one of several dark, smooth-floored craters located off the southeast shore of **Mare Serenitatis**. Its nearest prominent neighbours are 61km **Le Monnier** 150km to the north, 40km **Romer** 183km to the northeast and 30km **Vitruvius** 120km to the south. When the Moon is in a full phase, Littrow's dark floor stands out well, framed by lighter highland material surrounding it. Under such circumstances, the crater may be located approximately one-third of the way along the line from Romer towards 43km **Plinius** 290km to the southwest, close to the northern border of **Mare Tranquillitatis**.

Littrow is an old crater, which is revealed by its outer rim appearing irregular and heavily eroded. It has a teardrop rather than circular shape, the 'point' of the tear being located to the north of Littrow's outline. Its floor is smooth and lava filled. It contains a number of tiny craterlets, but these are hard to see. The largest of them sits near to the southern rim and measures 2km across.

To the northeast of Littrow, separated by a narrow strip of lunar highland, is 23km **Littrow A**, a crater that has a very similar appearance to Littrow itself. In fact, a scan around the area will show many dark, smooth lunar pools nestled within the bumpy highland terrain.

Heading west from Littrow brings you to the distinctive 7km diameter crater **Clerke**, which is located within the boundary of Mare Serenitatis. Clerke is a good stop-off point for **Rimae Littrow**, a series of grooves running through this region. They appear to head north and northeast from the headland material located immediately east of the ghost crater **Abetti**. Despite having a diameter of 17km, Abetti is totally submerged below the lava that marks the boundary between Mare Serenitatis and Tranquillitatis. Its faint ghostly outline is quite challenging to see and really needs a low sun-angle to make it stand out.

The eastern channels of Rimae Littrow pass just to the west of Clerke before heading north into a

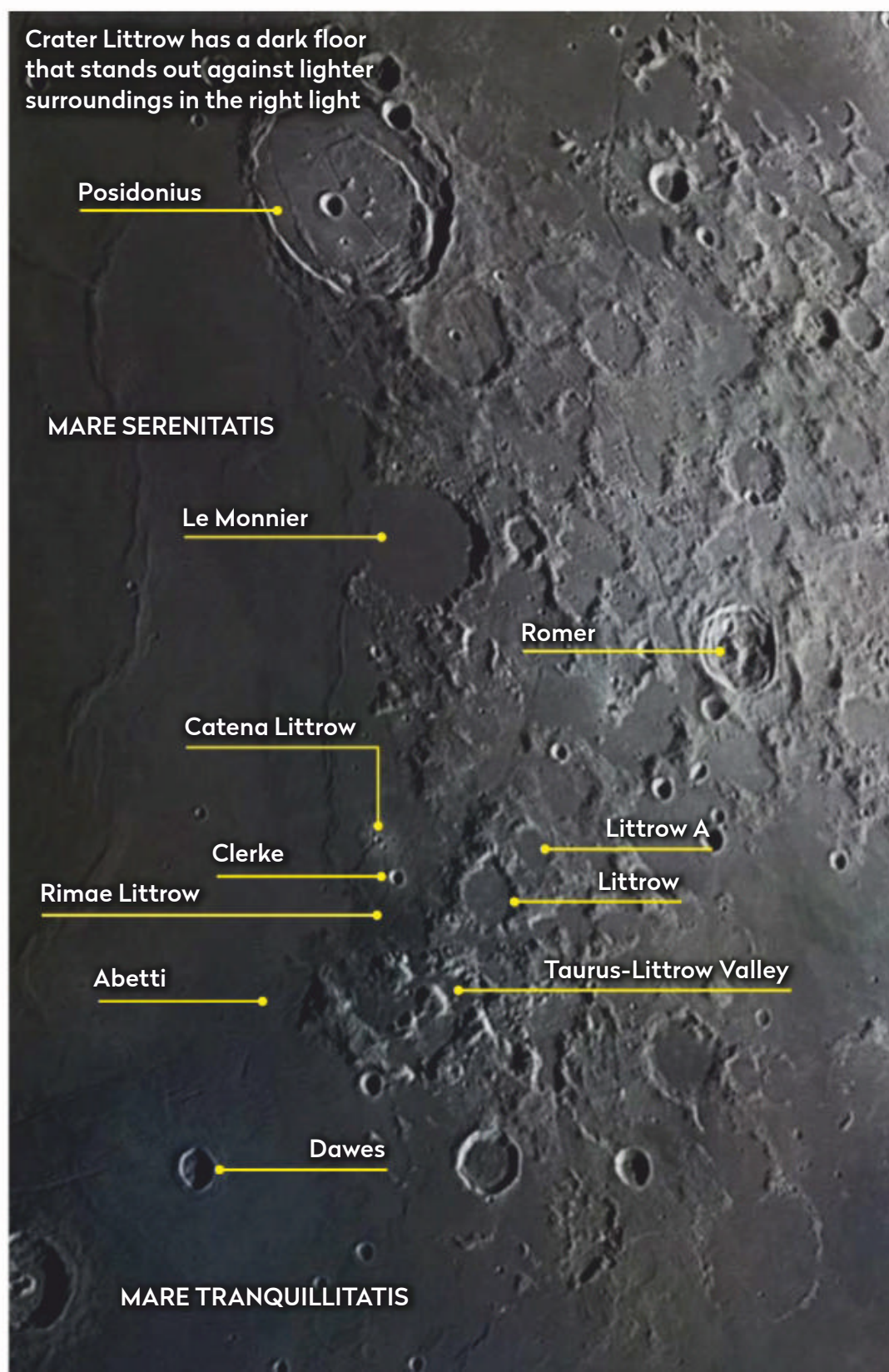
slightly brighter region of the Moon with several small craters, four of which appear joined in a line. These form a 10x3km feature known as **Catena Littrow**.

A dark, flat region 45km south of Littrow appears contained within a number of mountain peaks. These would have been formed at the same time as the impact that created Mare Serenitatis. The impact would have pushed material out and up, so creating the peaks and massifs we see today. The 30x30km dark-floored region represents a feature known as the **Taurus-Littrow Valley** after the proximity of Littrow and the Taurus mountain range in which it sits. Unlike many of the highly structured mountain ranges found on the Moon, the Taurus range occupies a large

150x150km region to the east of Mare Serenitatis, its peaks not appearing particularly connected to one another. The Taurus-Littrow Valley was the landing site for humanity's final (to date!) crewed mission to the Moon – Apollo 17.

"The impact would have pushed material out and up, so creating the peaks and massifs we see today"

Crater Littrow has a dark floor that stands out against lighter surroundings in the right light



COMETS AND ASTEROIDS

Why we're getting to see 46P/Wirtanen more and more often

We've been following the exploits of comet 46P/Wirtanen over the past few months as it brightened to naked-eye status and faded again. At present it's a binocular object which, although moving, remains within the constellation of Ursa Major, tracking close to mag. +3.1 Theta (θ) Ursae Majoris from 11 to 13 February.

Wirtanen is a short-period comet orbiting the Sun every 5.4 years. While no stranger to our skies, it is more difficult to see at some returns than others. It was discovered by US astronomer Carl Wirtanen using the 20-inch f/7.4 Carnegie Astrograph at the Lick Observatory in California, on 17 January 1948. A number of unfavourable returns followed, with the comet fulfilling the cliché of a 'faint fuzzy object'. A close pass of Jupiter in April 1972 reduced

the comet's orbital period from 6.7 to 5.9 years. This was further modified by another close pass of the gas giant in 1984, the orbit then being reduced to 5.5 years.

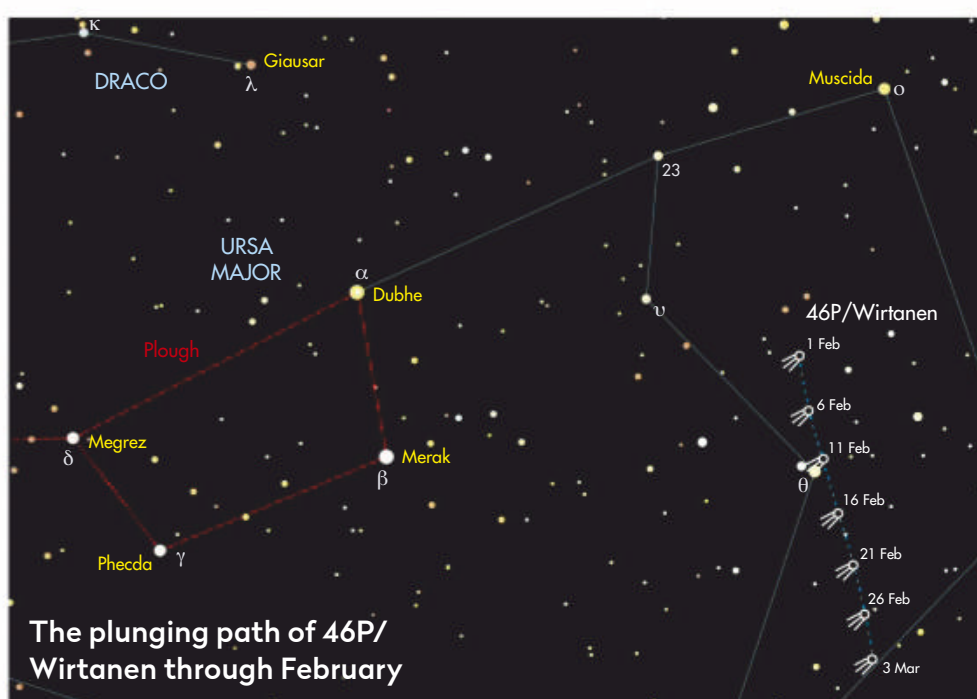
Favourable conditions for the comet's 1991 return resulted in it passing Earth by 1.4 AU and reaching an observed peak

magnitude of +10.0. The pass that just occurred brought 46P into naked-eye territory thanks to a very close encounter of 0.08 AU or 11.6 million km (7.2 million miles). It is not expected to appear brighter than this for at least another 20 years.

Comet 46P/Wirtanen was the original

target for the Rosetta spacecraft but was robbed of this fate by a missed launch window. As a result, Rosetta rendezvoused with comet 67P/Churyumov-Gerasimenko instead.

The nucleus of 46P/Wirtanen is quite small, with an estimated diameter of just 1.2 km (0.8 miles). For its size 46P shows a surprising level of activity, ejecting higher than expected amounts of water vapour, a characteristic it shares with a small group of similar comets.



STAR OF THE MONTH

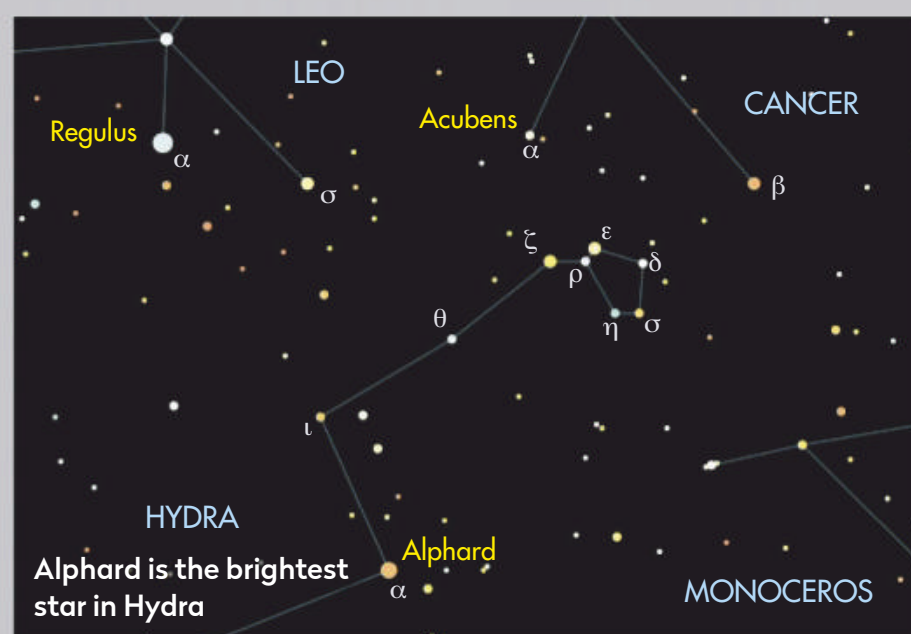
Alphard, a lonely orange giant in the throat of a vast serpent

Covering an area of 1,303 deg², Hydra, the Water Snake, is the largest constellation of all, but also a little obscure. Most of its pattern, representing the body of the snake, is marked by relatively faint stars. The head of the snake is more distinctive – a sideways tear-drop pattern south of Cancer, the Crab. The snake's 'neck' falls southeast of the head and it is here you'll find the orange giant star Alphard (Alpha (α) Hydrae).

Alphard is Hydra's brightest star at mag. +2.0, and it sits in an otherwise rather barren part of the sky. Appropriately, its name means 'solitary one'. Physically, Alphard is around 50

times larger than our Sun but contains only three times the mass. Its spectrum is K3II–III, the K3 meaning it is in the orange part of the stellar classification system that ranks stars according to temperature. The II–III indicates it's a class of star between a bright giant and a normal giant. Having exhausted much of its hydrogen, Alphard is now fusing helium into heavier elements such as oxygen and carbon in its core.

The star exhibits regular oscillations ranging from hours to days. It also has a small excess of barium. This is usually seen in binary systems where matter has been transferred



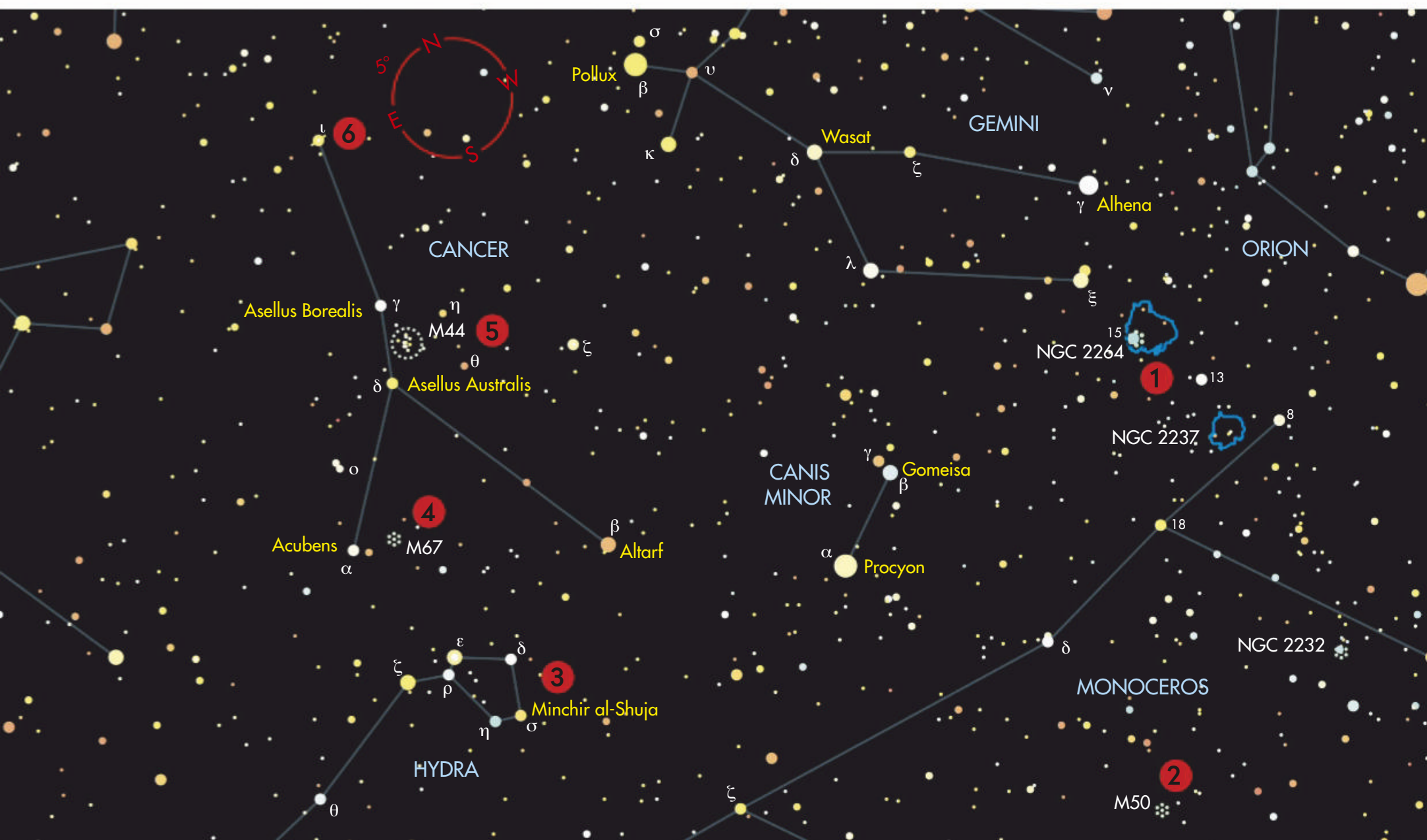
from a white dwarf. No such companion is visible close to Alphard. Two more distant companions can be seen, of

which only one, Alphard B, 282 arcseconds away, is considered to be a candidate for a true gravitational companion.

BINOCULAR TOUR

With Stephen Tonkin

A bit late, we pack up the Christmas tree and look for stars among a mythic battle



1 NGC 2264

10x 50 Although not quite the season now, let's start with the Christmas Tree Cluster (NGC 2264), 6.5° south of Alhena (Gamma (γ) Geminorum), surrounding the slightly variable (mag. +4.6 to +4.7) 15 Monocerotis. Intensely blue in binoculars, 15 Mon forms the trunk of this inverted conifer. The star at the tip of the tree is an easy binocular double. ☐ **SEEN IT**

2 M50

10x 50 To find this lovely open cluster, start at Procyon (Alpha (α) Monocerotis) then navigate two thirds of the way to Sirius (Alpha (α) Canis Majoris). M50 appears as a circular glow about half the apparent diameter of the Moon. This 78-million-year-old cluster lies 3,200 lightyears distant and spans about 20 lightyears. The glow comes from over 100 stars, but don't expect to resolve more than four or five of them, depending on the condition of your sky, in 10x50 binoculars. ☐ **SEEN IT**

3 Hydra's head

10x 50 Only part of the sky's longest constellation, Hydra, is visible from the UK. Its head is delineated by six stars between mag. +3.1 and mag. +4.4, but curiously only the faintest, Sigma (σ) Hydrae, has a common name, Minchir. Different cultures create different pictures from asterisms, and this distinctive group has been identified as a crab, a willow branch, a flag and a potter's wheel. Its colours range from the intense white of Eta (η) to the orange of Zeta (ζ). ☐ **SEEN IT**

4 M67

10x 50 Our final three targets are in Cancer, which in mythology was the giant crab Hera sent to try to prevent Heracles from slaying the Hydra. M67, which is slightly less than 2° west of Acubens (Alpha (α) Cancrī), is twice the apparent diameter of M50. It contains about 100 stars of the same type and approximate age as our Sun. ☐ **SEEN IT**

5 M44

10x 50 Just north-northeast of Asellus Australis (Delta (δ) Cancrī) is what looks to the naked eye like a little cloud – M44. It is a relatively close at 577 lightyears, and it has over 1,000 stars, more than any other nearby cluster, making it ideal for binoculars. It appears brighter in the middle. This is due to mass segregation: gravitational interactions between heavy and light stars send the lighter ones further from the cluster's centre. ☐ **SEEN IT**

6 Iota Cancri

15x 70 Iota (ι) Cancri is a true binary with an orbital period of 65,000 years. The mag. +4.0 primary is a yellow giant, and the secondary is a mag. +6.0 white main sequence dwarf. Only 30 arcseconds separate them, so if you have trouble splitting it, mount the binoculars and make sure you have perfect focus. ☐ **SEEN IT**

☒ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

Recording the ephemeral moon shadow phenomena known as clair obscur effects



▲ A sequence showing the formation of the Lunar X. The next appearance of the X will happen on the afternoon of 13 March

The Moon has many fascinating geological features to observe and image. Stark lighting passing across the lunar disc throughout the course of a lunar cycle brings life to them as an ever-changing tapestry of light and dark.

Human beings have a predilection for finding patterns in random irregularity. It's perhaps not surprising, then, that certain shadow and light formations on the Moon have been identified as looking like familiar objects or symbols. These are generally known as clair obscur effects. This month's challenge is to observe some of these effects and image them in a way that reveals their transient nature.

There is an extensive list of clair obscur effects on the Moon. Some are visible under full illumination, while most are visible only at certain times during the lunar phase cycle. An example of a full illumination effect is the L-shaped mountain located in Montes Caucasus between Maria Imbrium, Frigoris and Serenitatis. The reflectivity of this mountain is high, producing a sharp-cornered shape visible much of the time that it finds itself on the sunlit side of the Moon's globe.

Other more ephemeral shadow-based relief effects require timing and luck to see. The Moon's terminator has to be in a particular place which needs to coincide with the Moon actually being visible above your horizon. Even if these conditions are met, the weather can still ruin the show.

The location of the terminator is specified by a value called lunar co-longitude. This indicates the number of degrees the morning terminator (the one

that precedes the lunar daylight) lies west of Moon's prime meridian. At first quarter the co-longitude is 0° ; at full Moon it's 90° ; at last quarter it's 180° and at new Moon it's 270° . Accurate co-longitude values for any date and time can be obtained from free applications such as WinJupos and the Virtual Lunar Atlas.

This month there are several well-timed clair obscur events visible on the lunar surface (see page 44). Recording how they develop over a relatively short space of time is fascinating to do and really emphasises how transient they are. Whether you're a sketcher or imager, the technique that works best is to make

a record of the event starting, say, 1–2 hours before the optimum co-longitude is reached. Then continue making records at regular intervals through the peak and beyond. Intervals of 10 to 15 minutes work well.

Once you have your records, presenting them either in a time-based grid (as above) or perhaps as an animation works well to show how clair obscur effects form and disappear into the surrounding landscape. Some features don't last long at all, while others appear more resilient, visible throughout an entire night. By making these recordings you'll have a unique record of how these effects form.




▲ The Twin Spires of Messier appear not to resemble the features (the Messier craters) that produce them. They will be visible on the evening of 22 February at co-longitude 130°


DEEP-SKY TOUR

A selection of clusters and nebulae southwest of the constellation of the unicorn


1 M46

 M46 is a mag. +6.5 open cluster in the constellation of Puppis, the Poop Deck. It is located 5.3° to the south of Alpha (α) Monocerotis. The cluster is richly populated with stars and appears nearly 0.5° across. It lies about 5,400 lightyears from our Sun and is estimated to be around 300 million years old. Of its 500 or so members it contains approximately 150 that are in the range of mag. +10.0 to mag. +13.0. The brightest stars in M46 are white in colour, having a spectral type of A0. Physically, the cluster is estimated to be 30 lightyears across and has been measured to be receding from us at the speed of 149,040 km/h. **SEEN IT**

2 NGC 2348

 While M46 is rather beautiful to study with a small telescope, it hides an extra deep-sky secret. Located close to the cluster's northern boundary is a small planetary nebula catalogued as NGC 2348. This object has an apparent magnitude of +10.8 and a size of 1.1 arcminutes. However, NGC 2348 is estimated to be 2,900 lightyears from Earth. This makes the nebula significantly closer to us than the 5,400-lightyear distant M46. So although it looks as if NGC 2348 lies within M46, the connection is false, with the planetary appearing superimposed on the cluster due to a line-of-sight effect. **SEEN IT**


3 M47

 Rich though M46 appears, a wide-field view of the region will most likely draw your eyes to the west and to the much brighter open cluster, M47. At 30 arcminutes. This object is similar in apparent size to M46, but contains brighter stars. Its integrated magnitude is +5.2 and above the naked-eye threshold. It lies 1.3° west and slightly north of M46. Although recorded by Charles Messier on 19 February 1771, M47 had been discovered by Giovanni Hodierna before 1654. Messier's rediscovery was flawed by a recording

▲ Open cluster M46 with the deceptive NGC 2348 – which is 2,500 lightyears nearer to Earth – to the top left



error and M47 was regarded as a missing Messier until the error was identified in 1959. The cluster contains approximately 50 stars in a physical space 12 lightyears across. Its distance is about 1,600 lightyears. Through the eyepiece it's interesting to compare the coarse appearance of M47 with the smoother, but fainter, M46. **SEEN IT**

4 NGC 2423



 The brightness of M47 somewhat overwhelms another open cluster in the area, 38 arcminutes north.

NGC 2423 is a rich open cluster with an integrated magnitude of +6.7. A small telescope reveals over 20 stars in a 15 arcminute area. A ninth-magnitude star grabs the attention north of the cluster's centre. A 10-inch scope shows around 30 members in a larger 20 arcminute area. A 12-inch scope impressively doubles the count to 60 stars. The main central area of the cluster is around 13 arcminutes across. **SEEN IT**

5 NGC 2414

  Our clusters are getting smaller as we head to our next target, NGC 2414, which lies 1.2° southwest of M47 and has an apparent magnitude of +7.9. It's much smaller than any of the clusters so far encountered, with an apparent diameter of just 4 arcminutes. A 4-inch scope using a magnification of 150x will show around 15 stars clustered around an eighth-magnitude star (SAO 153056). Increased aperture brings ever more cluster members into view. A 10-inch scope reveals around 30 stars, a number of which appear to form an asterism reminiscent of a capital 'C'. NGC 2414 is a relatively young cluster estimated to be 9.5 million years old. **SEEN IT**

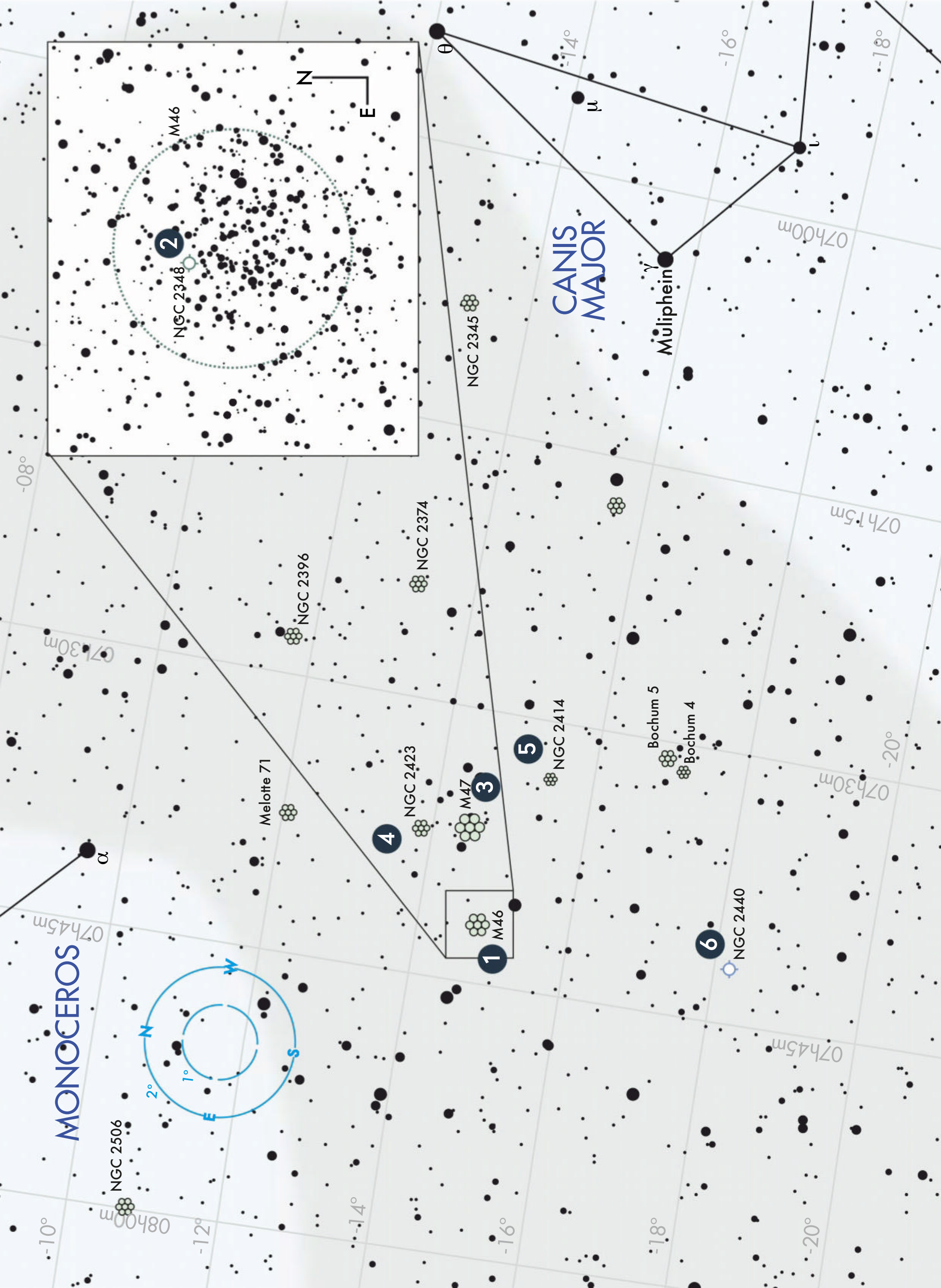
6 NGC 2440

  Our final target is a planetary nebula 3.5° due south of the centre of M46. NGC 2440 shines at mag. +9.4, making it suitable for small scopes, which show it as a glowing smudge. It's a relatively small, elongated object around 30x20 arcseconds and easy to mistake for a star in low magnification. At 100x it's clearly not a star, but much higher powers and aperture are needed to show any significant detail. There are two circular patches within the main elongated nebula, arranged at right angles to the long axis, which appear to almost touch. **SEEN IT**

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

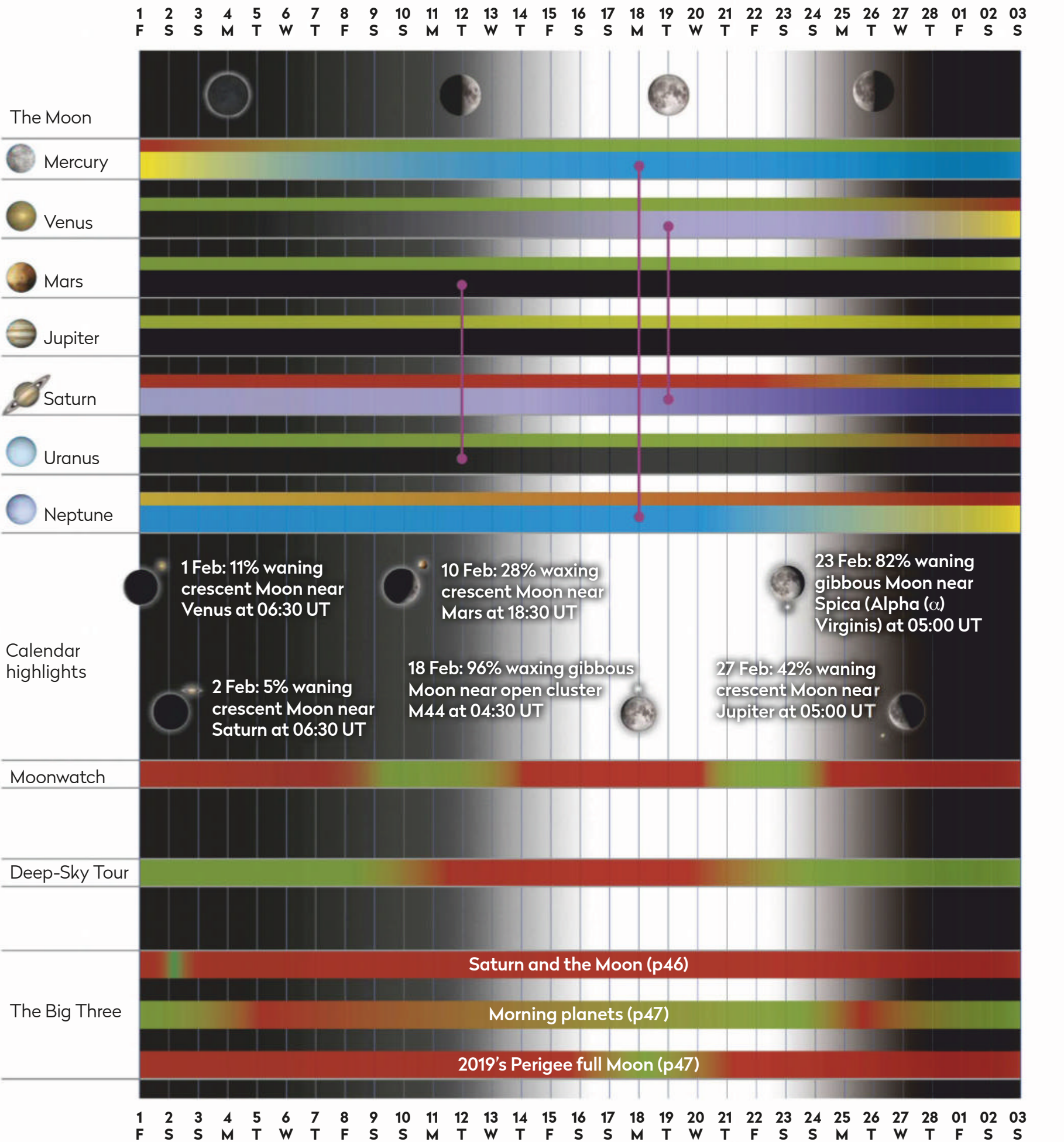


More
ONLINE
Print out this chart and take an automated Go-To tour. See page 5 for instructions.



AT A GLANCE

How the Sky Guide events will appear in February



KEY

Observability



Optimal Poor

Best viewed



Morning twilight Daytime Evening twilight Night

Sky brightness during lunar phases



Dark (first quarter) Light (full Moon) Dark (last quarter) Total darkness (new Moon)

IC

Inferior conjunction (Mercury & Venus only)

SC

Superior conjunction

OP

Planet at opposition

△

Meteor radiant peak

●

Planets in conjunction



Full Moon



First quarter



Last quarter



New Moon

OPTICS OF DISTINCTION



OSTARA

ELINOR

The award winning Elinor range has it all with an ultra wide field of view providing a high resolution, comfortable and an incredibly stable image. Features include large eyepiece lenses for very comfortable, long eye relief viewing.

The body has tough rubber armour and is waterproof.

All surfaces are fully multicoated further enhancing brightness and clarity. Optical Hardware's broad lightband transmission ensures incredibly accurate colour rendition.



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GUARANTEE

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The 2018 competition winners on display at the National Maritime Museum, Greenwich

Insight Investment Astronomy Photographer of the Year opens

Could you be a winner in 2019?

Whether you enjoy capturing the wonder of the night sky on a state-of-the-art setup or a humble smartphone, it's time to submit your best images for the Insight Investment

Astronomy Photographer of the Year (IAPY) 2019.

Now in its 11th year, IAPY is the world's leading astrophotography competition, welcoming entries from all abilities. It has grown substantially since its inception, both in terms of its prizes – with the overall winner now receiving £10,000 – and the scale of its venue. The ceremony and exhibition recently moved from the Royal

Observatory, Greenwich to the nearby National Maritime Museum.

In 2018 the competition received 4,284 entries from 91 countries. The overall winner was Brad Goldpaint's entry for the People and Space category, an image of a lone photographer in a remote Utah landscape against the backdrop of the Andromeda Galaxy, the Moon and the Milky Way.

Read on to discover which of the eight categories suit you best. In addition to £10,000 for the overall prize, there are prizes of £1,500, £500 and £250 for category winners, runners-up and highly commended entries, and £750 for each of the two special prizes. 🌌

NATIONAL MARITIME MUSEUM: BRAD GOLDPAINT, NICOLAS LEFAUDEX, STEVEN MOHR, JORDI DELPEIX BORRELL, NICOLAS LEFAUDEX, MARTIN LEWIS, FERENC SZÉVÁR, MARIO COGO, TIANHONG LI, DAMIAN PEACH, FABIAN DALPIAZ

Insight Investment
Astronomy ✨
Photographer
of the Year

Dates for your diary

Submission closing date: 8 March 2019

Exhibition opens: Autumn 2019

HOW TO ENTER AND RULES

To put yourself in the running to become the next Insight Investment Astronomy Photographer of the Year, and to read the full terms and conditions, visit the competition website: rmg.co.uk/astrophoto

CHOOSE YOUR CATEGORY

Enter as many categories as you like, as many times as you like

Aurorae



The stunning displays of Earth's two aurorae – the Northern and Southern Lights – offer a perfect opportunity for astro imagers to capture a night sky awash with colour. Charged solar particles interact with our atmosphere, creating a palette of green, pink and blue.

People and Space

Last year's overall winner was selected from this category, in which a person or a sign of human civilisation is set against a celestial backdrop. If you have an inspirational image that contrasts humanity with the vast majesty of the skies, this is the category for you.



Skyscapes

This category is an opportunity to combine creative flair with technical ability, to celebrate our planet's relationship with the heavens by framing an Earthly foreground with a starry night sky.



Stars and Nebulae

With over 200 billion stars and sprawling clouds of vividly coloured nebulae in our Galaxy, there are plenty of deep-sky objects from which to choose.



Galaxies

The light emitted from a distant galaxy may have started its journey millions or billions of years ago. This challenging category can produce stunning results, giving insights into the Universe's building blocks.



Our Sun

Capturing images of the Sun's seething activity gives us a valuable glimpse of its immense power. Sunspots, solar flares and plasma flows all make fascinating subjects.



Planets, Comets and Asteroids

Planets can prove elusive to catch, but the results can be breathtaking, while comets in the outer reaches of our system make striking targets.



Our Moon

Earth's only natural satellite offers plenty of scope for photographers. There are many ways to capture the Moon in its varying phases, whether up close or wide field.



SPECIAL PRIZES

The Sir Patrick Moore Prize for Best Newcomer

The British astronomy legend lends his name to this category, specifically for entrants who only started imaging in the past year.



Robotic Scope

The awards also recognise the latest innovations in imaging, and this category is open to anyone who uses cameras and telescopes operated remotely over the internet.



Young Astronomy Photographer of the Year

Here's a great opportunity for young astro imagers. If you're under the age of 16, showcase your talent in the IAPY Young Competition. There's £1,500 for the overall young winner, £500 for runners-up and £250 for highly commended entries.





Dr Elizabeth Pearson is BBC Sky at Night Magazine's news editor. She gained her PhD in extragalactic astronomy at Cardiff University

A galactic FEAST

Elizabeth Pearson finds out how Gaia is revealing our Galaxy's gluttonous past

The Milky Way is a cannibal. Like most other large galaxies, it has grown into the spiral we know today by feasting upon its smaller brethren. But these consumed galaxies are not entirely gone. In 1994,

astronomers found the remains of a dwarf galaxy that had been consumed – or accreted – by our own billions of years ago.

Since then, they've uncovered the bones of several other small galaxies, but seen no sign of the big galaxies that merged together with the Milky Way. Finding those traces requires a much closer look at the hundreds of billions of stars with which we share the Galaxy.

Enter Gaia. For the last five years, the European Space Agency's Gaia spacecraft has been creating the most detailed map of the Milky Way ever made.

Turning back time

"Gaia is the first of its kind. It's telling us what the Milky Way is like in three dimensions," says Professor Gerry Gilmore from the University of Cambridge, one of the principal investigators of the Gaia mission.

Gaia is not just mapping star positions but velocities as well. Astronomers can use these to track a star's orbital path, then rewind their motions to work out where stars originally came from. By doing this for stars across the Milky Way, it's possible to reconstruct the history of our Galaxy's growth. In some cases, a star's origin lies

beyond our Galaxy. However, to backtrack stellar motion accurately scientists have to find stars that have remained in a similar orbit for billions of years.

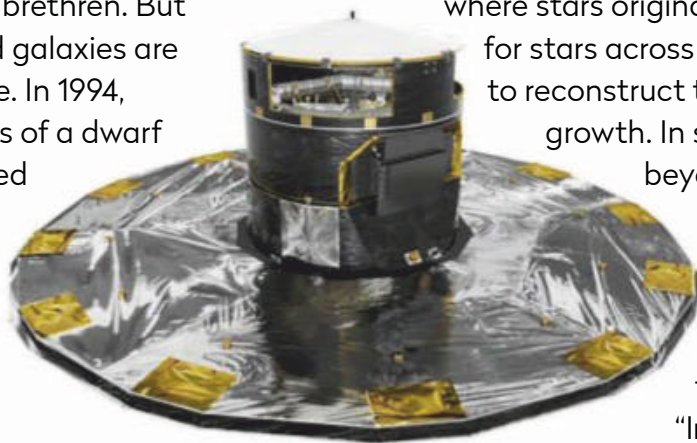
"In the plane of the Milky Way, the spiral arms move much faster, rotating around once every 100 million years, like a

giant egg beater mixing everything up," says Gilmore.

Unable to find what they needed in the disc, astronomers began looking at the halo of stars swarming around the outer regions of the Galaxy.

"In the halo, timescales are very long – stars take one billion years to go around and nothing much happens. Stars high up out of the plane of the Galaxy retain the memory of where they came from in their motion," says Gilmore.

Only a tiny fraction of stars Gaia observed are both in the halo and bright enough to take full ▶



▲ ESA's Gaia spacecraft has pinpointed over one billion celestial objects



Gaia has shown that
at some point in
the past our Galaxy
collided with another
which was far bigger
than we first thought



Sagittarius dwarf galaxy

▲ Gaia revealed that a near hit with the Sagittarius dwarf galaxy 300–900 million years ago triggered odd ripples in our Galaxy

► velocity measurements, but even from this tiny sample, one set of stars immediately stood out.

“There’s a very large group of stars that were moving in the opposite direction to the other stars in our Galaxy,” says Amina Helmi from the Kapteyn Astronomical Institute in Groningen, whose team was one of those investigating these stars. While most stars rotate clockwise, a group of around 33,000 were moving anticlockwise.

“This hinted to us that this is strange. They could be a population that was accreted, because if stars

were from the Milky Way itself you would expect, to some extent, that they would move like all the other stars,” says Helmi.

A galactic banquet

The real smoking gun came when the team cross-referenced these stars with the results from another survey, the APO Galactic Evolution Experiment (APOGEE), which looks at the chemical composition of stars. The stellar chemistry suggested that these stars all came from the same galaxy, but this galaxy

High-velocity invaders!

Some stars were thrown out of their galaxies before arriving in ours

Not all the stars the Milky Way has gobbled up came in as part of a galaxy. Some arrived as lone invaders.

Astronomers have been sifting through the Gaia data looking for the fastest stars in the Galaxy. These hypervelocity stars are thought to have been accelerated to enormous speeds by a close pass with the supermassive black hole at our Galaxy’s centre, or some other cataclysmic event. They are travelling so fast they could potentially escape our Galaxy’s gravitational hold.

Astronomers were hoping to find one or two stars like this being thrown out of our Galaxy. They found 20. Rather than escaping the Milky Way, many of them

were rushing inward, having not been ejected from our Galaxy but another. Now they are infiltrating the Milky Way.

The stars probably originated in one of the two Magellanic Clouds – small dwarf galaxies which lie close to the Milky Way.

“We would expect to find things like that coming out of the Magellanic Clouds,” says Gaia’s Gerry Gilmore. “It’s also certain, on physics grounds, that there are a huge number coming from Andromeda as well, but we haven’t found them yet.”

Scientists were surprised to find hypervelocity stars speeding towards the Milky Way’s centre



► Known as parallax, the apparent shift in a star's position over time allows us to calculate its distance

Mapping a Galaxy

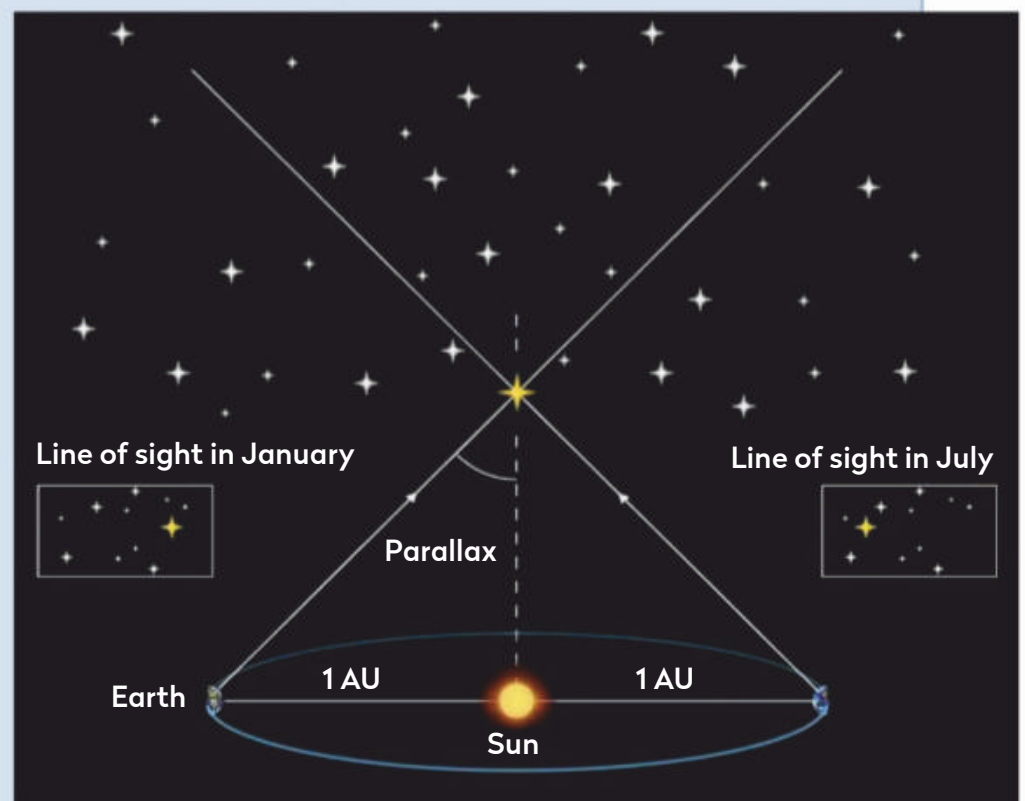
Gaia's data will take over a decade to analyse

Gaia launched on 19 December 2013 and now flies 1.5 million kilometres behind Earth as it orbits the Sun. During its mission, Gaia has imaged over a billion stars multiple times to map the Milky Way. While measuring a stellar position on the sky in two dimensions is relatively straightforward, tracking things along the line of sight to a star is a lot trickier.

To measure the distance to a star, Gaia uses a technique known as parallax. The team compares two images of a star taken from opposite sides of the Solar System. The difference in observing location causes the star's apparent location to shift, and astronomers can use this to estimate the distance – the less a star moves, the further away it is.

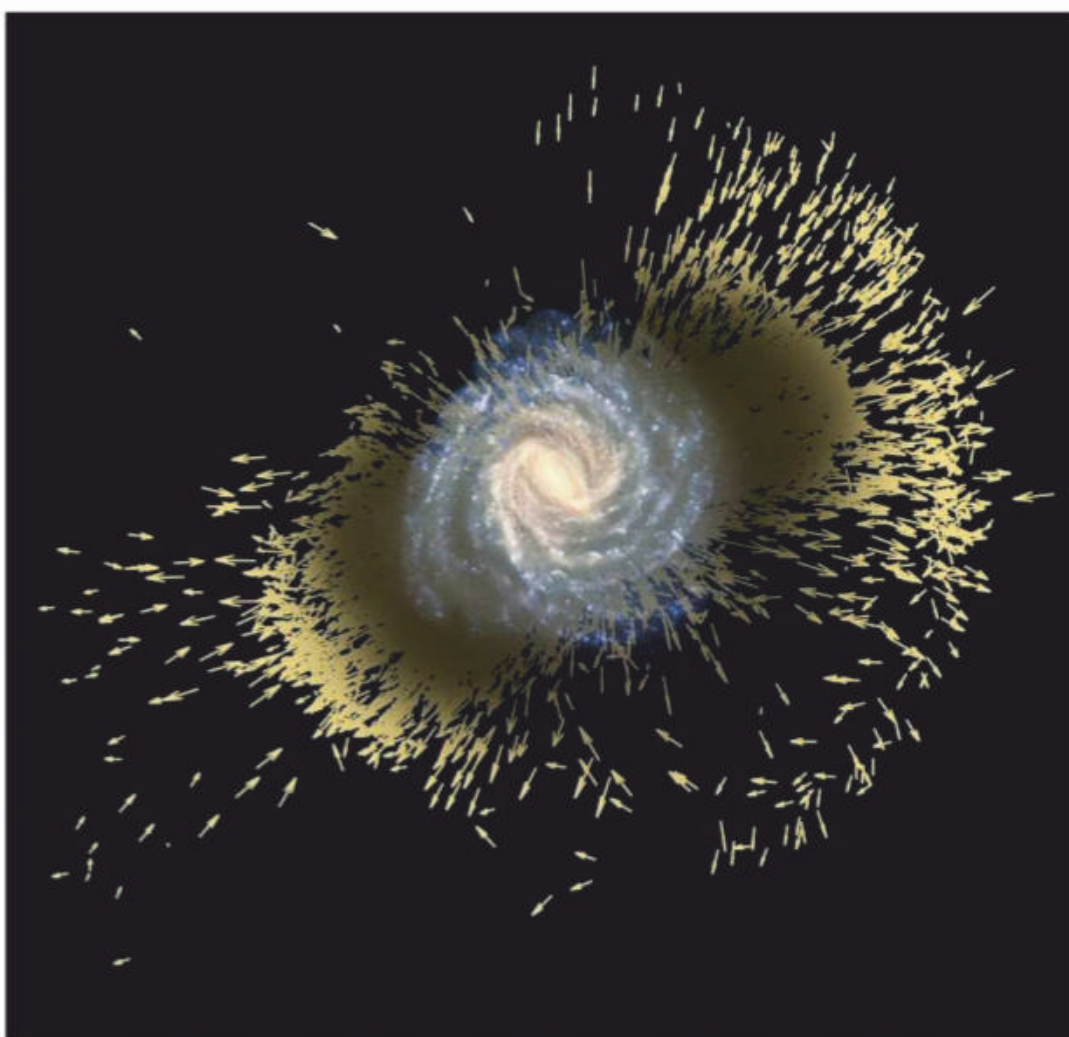
In total, Gaia has observed each star around 70 times. As well as ensuring precise parallax distances, these repeat observations mean researchers can track how the stars are moving across the sky and through the Galaxy.

For the brightest stars, it's possible to measure how fast they move along our line of sight using what's called redshift spectroscopy. Within a star's light are special signatures called spectral lines which are always created



at the same wavelength. The speed of a moving object can cause this wavelength to shift, and astronomers can measure this change to predict how quickly a star is moving away or towards us.

All these observations have produced a huge amount of data. Though the Gaia mission is due to end in 2019, it will take years to fully process its trove of data and decades for astronomers to trawl through it. Gaia's story is far from over.



▲ An artist's impression of the debris from Gaia Enceladus's merger with the Milky Way

did not appear to have originally been the Milky Way. "It was immediately clear these stars had to have been born elsewhere," says Helmi.

From the remains of the merger, Helmi's team were able to calculate that the colliding galaxy – now known as Gaia Enceladus – was a mammoth 600 million times the mass of the Sun, around 25 per cent of the mass of the Milky Way at that point. This was no snack on a dwarf galaxy: this was a banquet on a galactic scale.

Just after the cosmic feast, the influx of gas would have created a burst of star formation. Many of the

"The colliding galaxy – now known as Gaia Enceladus – was a mammoth 600 million times the mass of the Sun"

33,000 stars picked out by the Gaia data were born at this point – within the Milky Way, but from the gas of the colliding galaxy. "The youngest stars are 10 billion years old," says Helmi.

The Milky Way's past feasts

But as the two bodies finished merging the interloper was torn apart, stopping any new stars from forming. "That's how we date the end of the merger, though it probably started 11 to 11.5 billion years ago. It takes a few billion years for a galaxy to be subsumed," says Helmi. "I think this was the last big merger that the Milky Way experienced."

While this might have been the most recent and most obvious big merger our Galaxy has had, it's almost certainly not the only one. Finding traces of any previous mergers, however, will take an even more detailed examination of the Milky Way. Currently, Gaia has full velocity measurements for just 7 million of its billion stars. As the mission gathers and analyses more data, that number is growing, and by the end of Gaia's survey astronomers hope to have velocity measurements for around 150 million stars. Perhaps amongst this glut lies another galactic gate-crasher the Milky Way has swallowed up whole. 🌌

EXPLAINER

Understanding the Moon's monthly cycle

There's a logic behind what our satellite looks like and where it'll be at any given time

Go and look at the Moon. On average 384,400 km from Earth, it's stunning to the naked eye and through binoculars or a small telescope, spectacular. It seems serene but is hurtling eastward at 3,682 km/h and, since its almost circular orbit is tipped a mere 5° relative to Earth's, it more or less follows the ecliptic (the Sun's apparent path) across the sky.

You may have noticed that the Moon always keeps the same face turned towards us. This is because it rotates once on its axis in exactly the same time it takes to orbit Earth – 27 days and seven hours. This synchronisation is called tidal locking and is a result of Earth's gravitational effect on the young satellite when it was forming.

During its elliptical journey around Earth, the Moon moves through 'phases', the term we use to describe how much of the lunar disc appears illuminated as seen from Earth. In fact, the Moon is always half lit, we just don't see it that way. Whatever phase we're seeing, the opposite phase is happening on the far side. And while we only ever see one terminator (the name given to the dividing line between the light and dark parts of the lunar surface) sweeping right to left across the lunar disc at any time, there are actually two of them circumnavigating the Moon exactly 180° apart; the morning terminator (which ushers in the lunar day) and the evening terminator (which brings

the night behind it). So sorry, Pink Floyd, there is no permanently dark side of the Moon.

Phases set to stun

What many people don't realise (even though it's completely logical), is that there's also a relationship between the Moon's phases and moonrise times.

New Moon: In this phase, our satellite is invisible. With the Sun and Moon on the same side of Earth, they rise together but we cannot see the Moon as it's hidden in the Sun's glare. There's not much to see anyway, as its face towards us is totally in shadow.

Waxing crescent: Continuing its journey, the Moon's western (right) edge becomes sunlit to create a sliver-thin crescent. The morning terminator starts its creep of 15.5km/h from west to east.

First quarter: This one confuses non-astronomers, because it clearly looks like half a Moon, yet it's called a quarter Moon. That's because the terminator has completed a quarter (90°) of its 360° journey around the Moon. (By this logic a full Moon should be called a half Moon, but that's just silly, right?) In this phase, the Moon rises at noon and sets at midnight. Along the terminator, low-angled sunlight creates long shadows, throwing nearby crater and mountains into sharp relief – perfect for lunar observations.

Waxing gibbous: In this phase the Moon is almost fully illuminated. The daylight area appears egg-shaped (gibbous) and is increasing in size (waxing) daily.

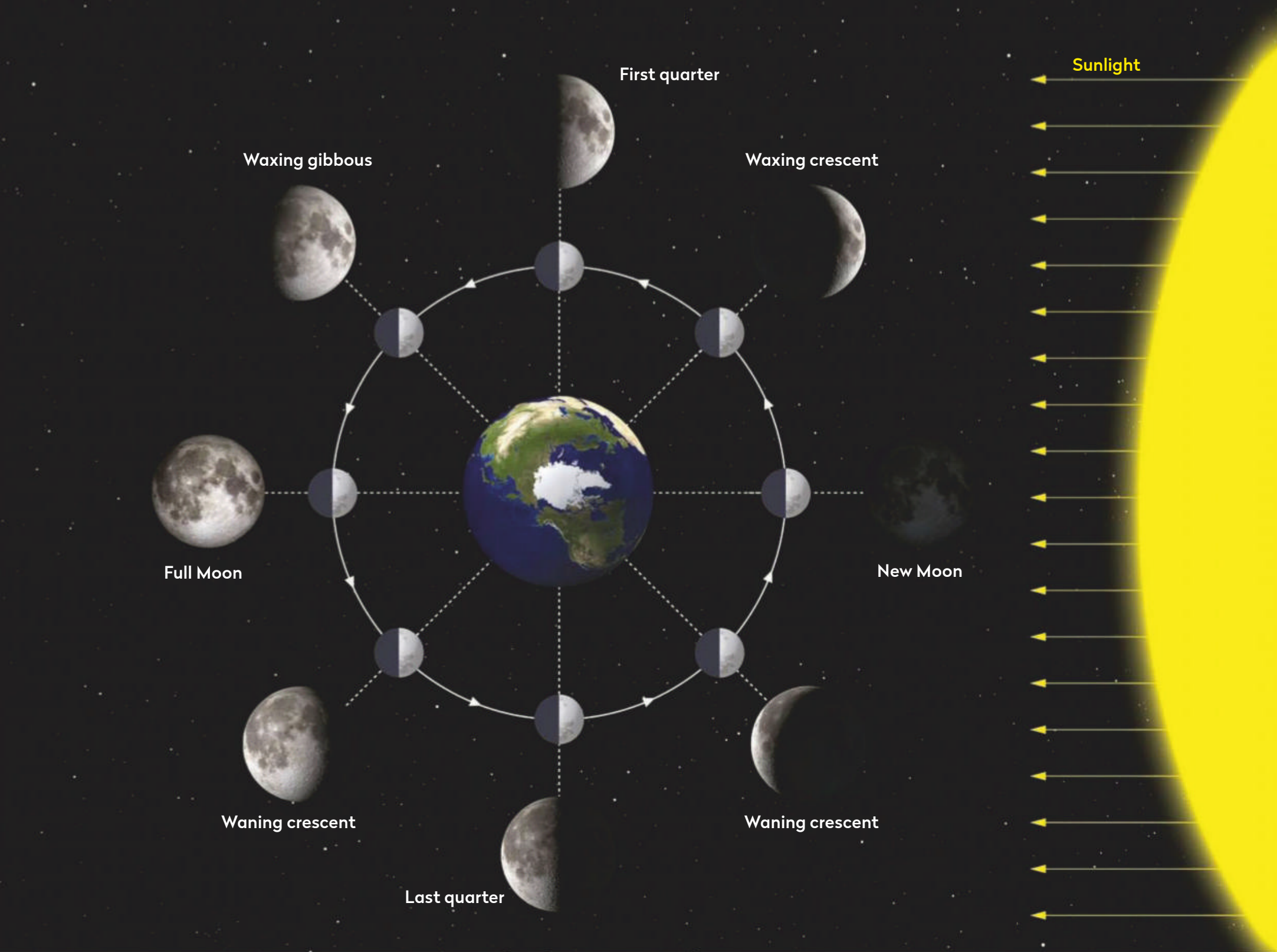


Jane Green is a fellow of the Royal Astronomical Society and author of the *Haynes Astronomy Manual*

▼ The Moon may always keep the same face turned to us, but the terminator makes sure that face keeps changing

ISTOCK, STEVE MARSH X 2





▲ The inner circle shows what the Moon looks like seen from above its north pole, while the outer circle shows the phase we see from Earth at that time

Full Moon: Halfway through the morning terminator's journey, the Moon is on the opposite side of Earth from the Sun, with its near side fully illuminated and dazzling. Shadow-less, bleached and flat-looking, it's not good for observation – that's a shame because in this phase it rises as the Sun sets, sets as the Sun rises and is visible all night long!

Waning gibbous: The Moon's western edge is being consumed by darkness as the evening terminator comes into view. The sunlit, egg-shaped area is diminishing (waning).

Last quarter: It's seven days and nine hours since full Moon and, now 90° west of the Sun, just the Moon's eastern (left) half is illuminated. At this phase it rises at midnight and sets at noon and, like the first quarter phase, offers staggering views.

Waning crescent: With just the eastern edge sunlit you'll admire a beautiful 'C-shaped' crescent. Diminishing daily (waning) it will soon disappear as the lunar cycle concludes and the Moon returns to 'new'.

While the Moon may keep the same face turned to us, it remains a daily changing delight to observe. 🌕

Lunar Libration

Over the course of a lunar cycle, the Moon simultaneously wobbles both latitudinally and longitudinally. These oscillations are known as librations.

Libration in latitude – nodding – occurs because the Moon's axis is slightly inclined relative to Earth's, enabling us to peer just a

little over its north and, later in the month, south poles.

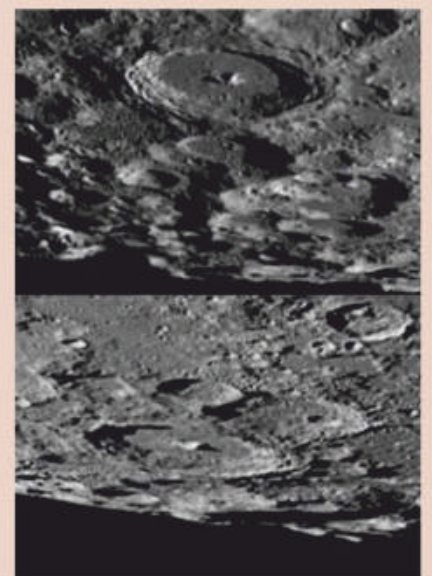
Libration of longitude – shaking – occurs because the Moon travels fastest when closest to Earth and slowest when farthest away.

Daily (diurnal) libration occurs because of our planet's rotation. We see the Moon from slightly different perspectives when it rises

► Crater Moretus at the Moon's south pole shown at different ends of the lunar libration period

and when it sets, and this difference in perspective manifests as a slight apparent rotation in the satellite, first to the west and then to the east.

The combined effect of all the above means that instead of seeing just 50 per cent of the Moon, over time we actually get to see about 59 per cent.



BBC Sky at Night
MAGAZINE

BACK GARDEN ASTRONOMY

WEEK

2-10 February



Discover the wonders of the night sky one simple step at a time – we'll make it easy!

Have you always wanted to discover the best the night sky has to offer but just don't know where to start? If so, then **Back Garden Astronomy Week** is for you!

Launching in February, *BBC Sky at Night Magazine* will introduce the wonders of stargazing in easy-to-do, nightly observing instalments.

Just sign up and each day from **Saturday 2–Sunday 10 February** we'll send you a no-nonsense email newsletter that will help you discover a new sight every night.

We'll show you how to find some of the most magical objects in the night sky, all of which will be visible from your back garden with just a pair of binoculars.

You don't need to travel far to find beguiling star clusters, bright planets, regions where stars are being born now and even distant galaxies beyond our own.

Each day during **Back Garden Astronomy Week** you'll also get essential observing tips that beginners need – advice like how to get your eyesight used to the dark, how best to navigate the night sky and which are the best targets to see.

Sign up today to kickstart your journey of discovery to the stars and we'll send you a **free 50 page digital starter pack!**

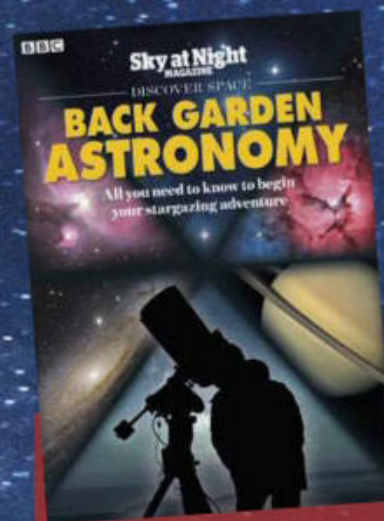
Sign up today!

► Visit www.skyatnightmagazine.com/backgarden to sign up in a few easy steps

BACK GARDEN ASTRONOMY WEEK

2-10 February 2019

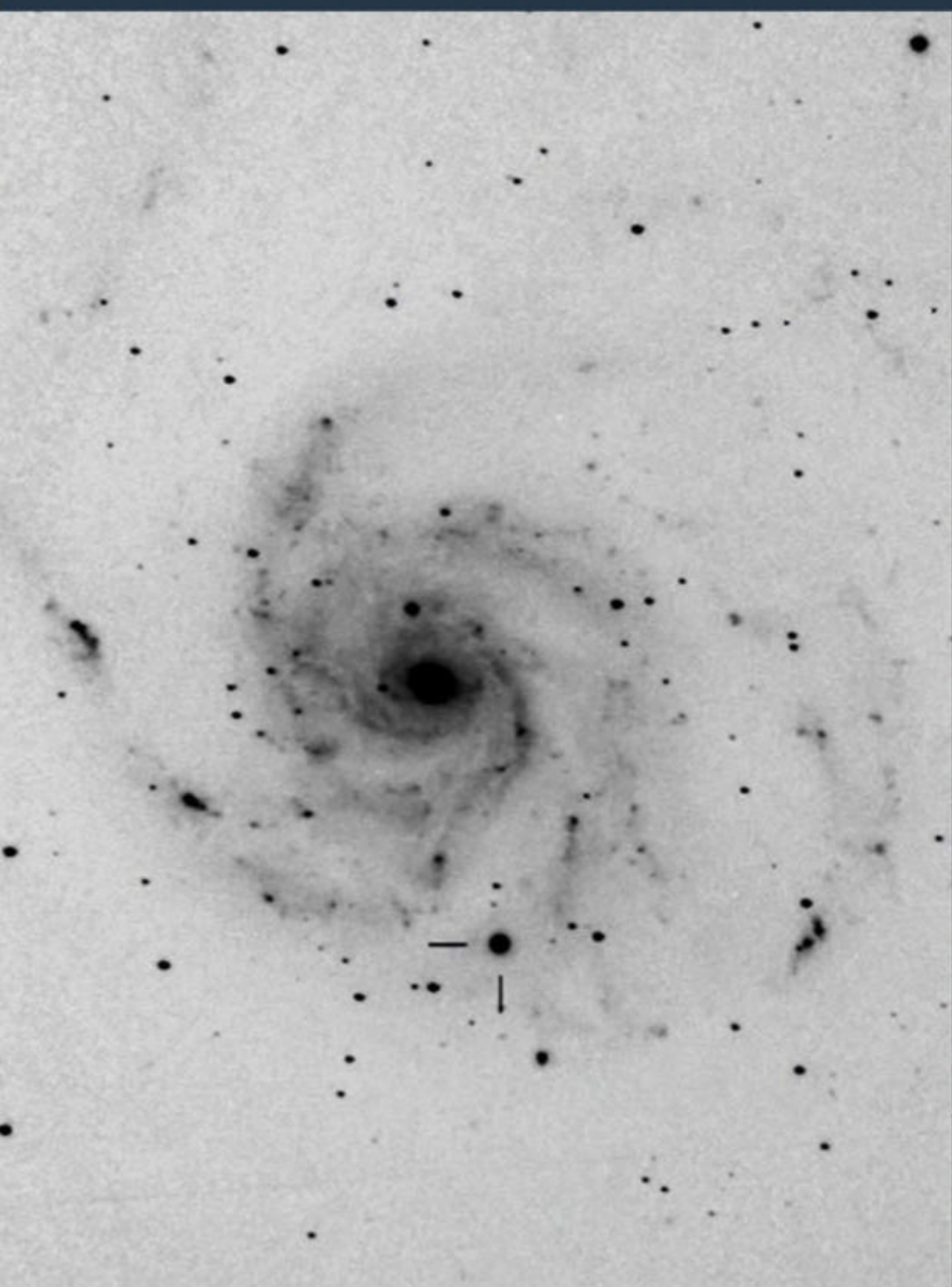
DISCOVER THE STARS



FREE
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Imaging for SCIENCE



Supernova SN2011fe in
Messier 101 – supernova
hunting is an important
activity ideally suited
to amateur astro imaging

PART 10: DEEP SKY

Some of the most dazzling, colourful images from space come from amateur deep-sky photographers. But, with care, says **Pete Lawrence**, they can also advance our understanding of the cosmos

PETE LAWRENCE



◀ Some deep-sky objects show relatively short timescale variation, such as Hubble's Variable Nebula and McNeil's Nebula near M78, indicated here. In November 2018 McNeil's Nebula disappeared from view



The Sky at Night presenter **Pete Lawrence** is an astrophotographer with a particular interest in digital imaging

Deep-sky photography can be a difficult area of astrophotography to associate with scientific observation. This is because it attracts a huge following of imagers who often produce results optimised for visual rather than scientific appreciation. There are several reasons for this. Deep-sky objects are very distant and there's a belief that they don't change appearance significantly over time. In addition, these often very beautiful objects nurture a desire to present them at their best. Treating a deep-sky image as a scientific recording seems inappropriate when large professional telescopes can do it so much better.

But there is in fact much scientific work that can be done by astrophotographers. Their images can lead to a better understanding of the nature of the objects being photographed, reveal surprises and

bring an overall richer appreciation for the workings of the Universe. Best of all, there is room for both aesthetic and scientific presentation using the same image data.

Hardware & software

HARDWARE

- ▶ Telescope
- ▶ Equatorial mount
- ▶ Autoguider
- ▶ Camera (DSLR, cooled astronomical CCD, high frame rate)
- ▶ Laptop

SOFTWARE

- ▶ PixInsight
- ▶ Photoshop
- ▶ GIMP
- ▶ AutoStakkert!
- ▶ StarTools
- ▶ DeepSkyStacker
- ▶ APT
- ▶ Sequence Generator Pro
- ▶ Maxim DL

SUBMIT YOUR PICTURES FOR SCIENCE



"Although much of deep-sky observing might be classed as 'recreational', a scientific approach is recommended for anyone seeking

reliable and reproducible results," says Callum Potter, director of the British Astronomical Association's (BAA) Deep Sky Section (pictured). "And there are scientific deep-sky observing programmes to which amateurs can contribute. The BAA's Deep Sky Section has a long-term

programme observing variable nebulae (VNe). There are just a few targets, and their variability is due to changes in the star that illuminates the nebula rather than physical changes in the dust and gas of the nebula itself.

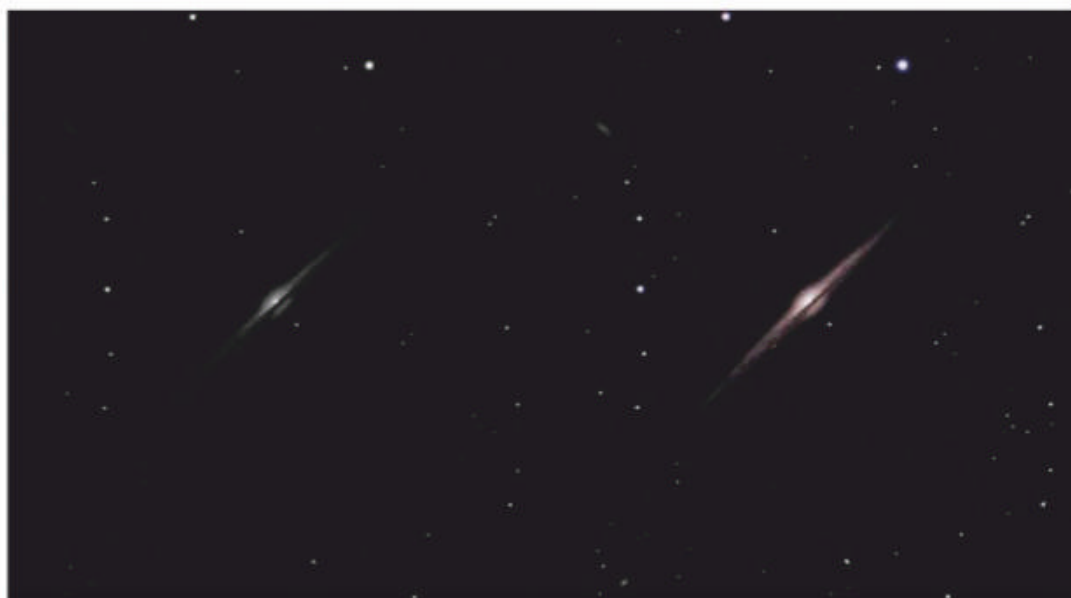
Mike Harlow of Orwell Astronomical Society Ipswich recently noticed the almost complete disappearance of McNeil's Nebula, which lies close to Messier 78. And surveying for new variable nebula in the dustier parts of the Milky Way is a project that amateurs can pursue. Professionals also engage with amateurs, and an

example is the HOYS-CAP project which processes images of common deep-sky objects in the search for young, outbursting stars. It is not unusual for new objects to be discovered in deep-sky images: comets, novae, supernovae, asteroids. And if you don't discover one yourself it's possible you might have a pre-discovery image like with the supernova discovered in M82 (SN2014J). Real science can be derived from such observations - so it's always important to keep your calibrated but otherwise unprocessed data."

PROJECT 1

Not just a pretty PICTURE

Strike a balance between aesthetics and scientific value



▲ Although there's a strong desire for colour images of deep-sky objects, more often than not it's raw mono components that have the greatest scientific value

The term 'deep sky' generally relates to anything that lies outside the Solar System. This encompasses stars in single, multiple or clustered collections along with a whole host of objects both internal and external to our own Milky Way Galaxy. The form, colour, variety and beauty of these objects are vast and imaging them can become a compulsive pursuit, requiring a set of skills unique to this area of astrophotography.

The question of image manipulation is perhaps most relevant in deep-sky imaging and the type of manipulation can strip or enhance an image of scientific merit. Unedited images may look visually

unappealing, but they potentially contain the most scientific worth.

Ultimately it's up to you as an imager how you want to present your results. A good strategy is to create an archive to hold the original images in case they are required for further scrutiny at a later date.

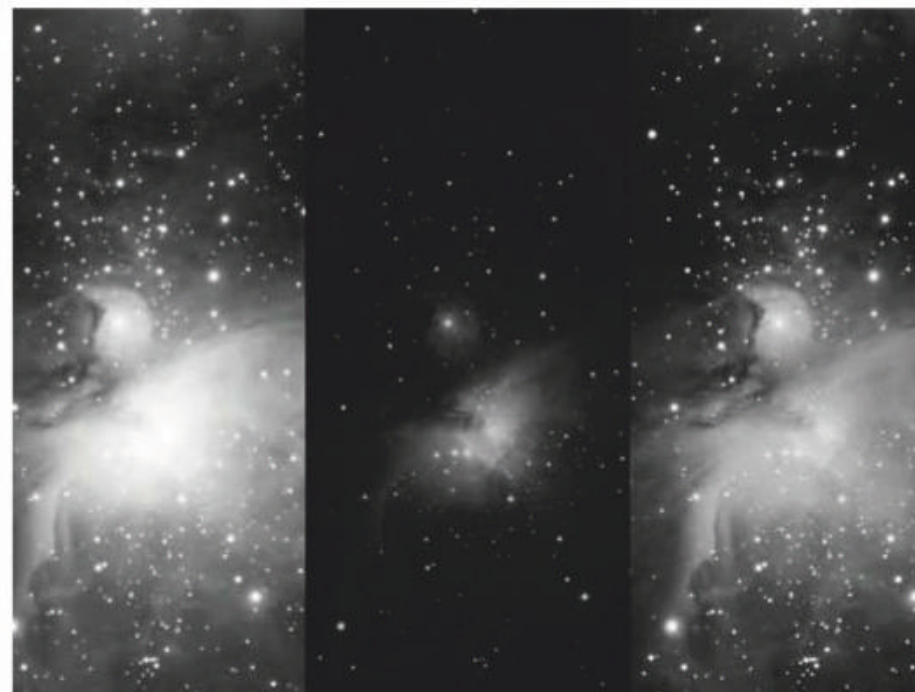
Most amateur astrophotos are manipulated to a degree. Stacking, noise reduction, brightness stretching and more, all produce results that are based on the original recorded data but have been adjusted to produce something new.

But how much manipulation is too much manipulation? The answer is open to subjective interpretation. Adjusting an object's colour may produce a correct-looking result but this could easily be incorrect, simply reflecting a stereotype colour gained from looking at professional images or the work of other amateurs. Few deep-sky objects are bright enough to provide a definitive visual colour reference to work toward.

For greatest visual impact it's common to want to pull out every last detail contained within the image. Here too caution must be applied because producing a high-dynamic-range (HDR) end result may show all of the detail recorded, but there will be a degree of subjectivity involved that ultimately relies on the processing and compositional skills used to create the final image. ►



▲ Although 'deep sky' implies objects outside our Galaxy, comets bridge the gap somewhat. Deep-sky imaging is well suited to recording their diffuse details



▲ High-dynamic-range (HDR) techniques can reveal faint details while retaining information in brighter regions

PROJECT 2

Image annotation and PRESENTATION FOR SCIENCE

Keep a clear record of your image and the equipment you use



▲ A DSLR will reduce processing workload for colour images, but a monochrome, cooled astronomical camera plus filters will provide more scope for scientific imaging

Deep-sky images are typically recorded with one-shot colour cameras or mono cameras and filters. One-shot colour cameras remove a lot of the hard work, but mono cameras with filters provide more scope for scientific imaging.

A common method of processing and combining mono, colour-filtered images is to concentrate on producing a high-quality luminance image to which colour-filtered images can be added for a full-colour result. In addition, speciality filters can be used to record specific wavelengths produced by certain elements. Common examples include H-alpha, H-beta, SII and OIII.

The results can be presented in a number of ways. A familiar example is the so-called Hubble palette. This is typically achieved by substituting RGB components with those taken through SII, Ha and OIII. The end result does not represent what you'd see visually but it does produce an image in which it's possible to see the contributions of sulphur (SII), hydrogen (Ha) and oxygen (OIII).

In addition, some mono results may be recombined into the luminance component, or replace it completely. A common example is to use an H-alpha filtered image of a nebula to further enhance the luminance part. This makes the luminance sharper and more defined than that produced by a conventional multi-wavelength luminance filter.

An issue arises as to how this information is conveyed to the viewer. Date and time stamps are very important as well as details of the telescope, camera and any other optical elements used in the imaging train. For multi-filtered images, filters should be identified along with the exposure times and number of sub-frames used for each filter. Finally, orientation markers, scale lines and star identification can be added to make interpretation easier. Your name and location should also be recorded.

As long as the original calibrated but unprocessed components have been archived for easy retrieval, the scientific elements of the image can still be analysed should further investigation be required.



◀ The inner region of the Rosette Nebula rendered using the Hubble palette with SII for the red channel, H-alpha for green and OIII for blue

▼ Clockwise from top left: H-alpha, H-beta, SII and OIII narrowband filters produce dramatically different views of the Horsehead Nebula



PROJECT 3

Image CALIBRATION

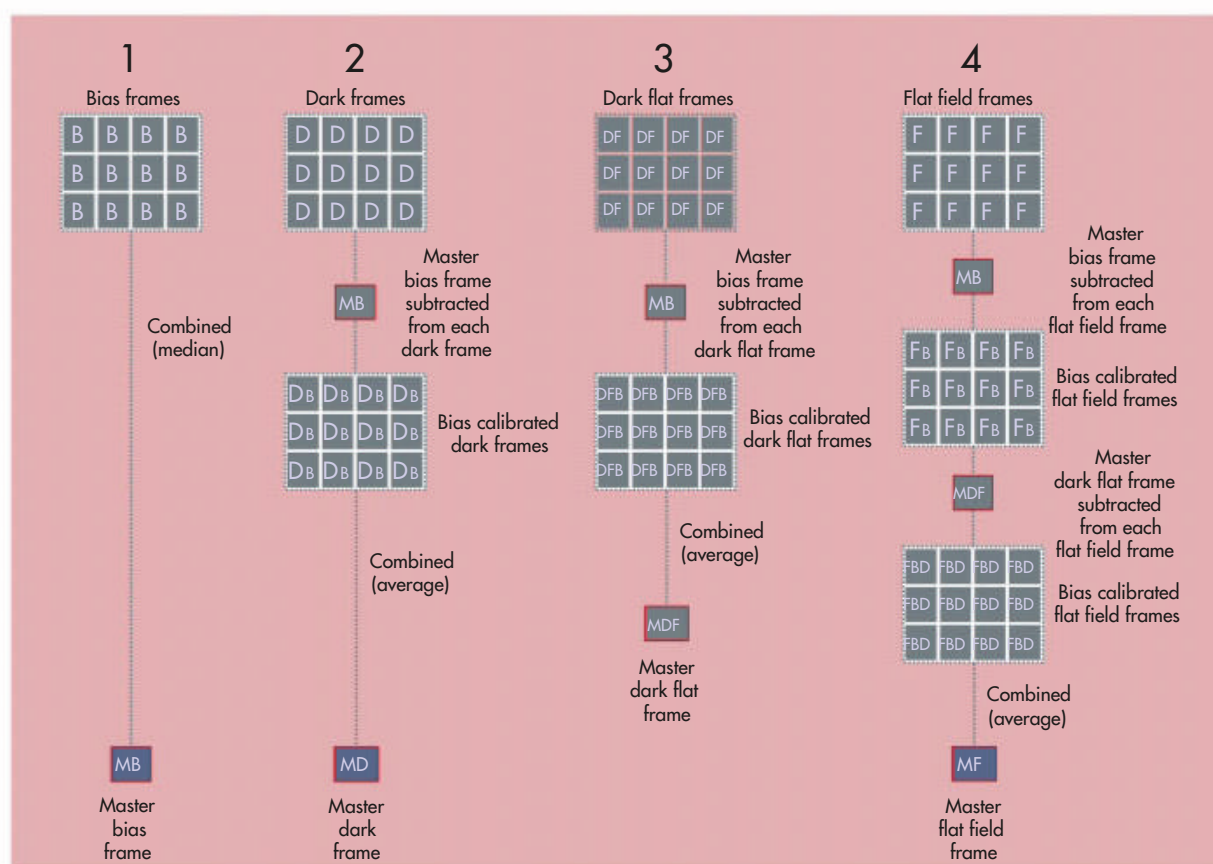
Process your deep-sky images to remove extraneous data

Image calibration removes elements from an image that shouldn't be there. There are various calibration steps that can be applied but care and understanding is required to use them correctly.

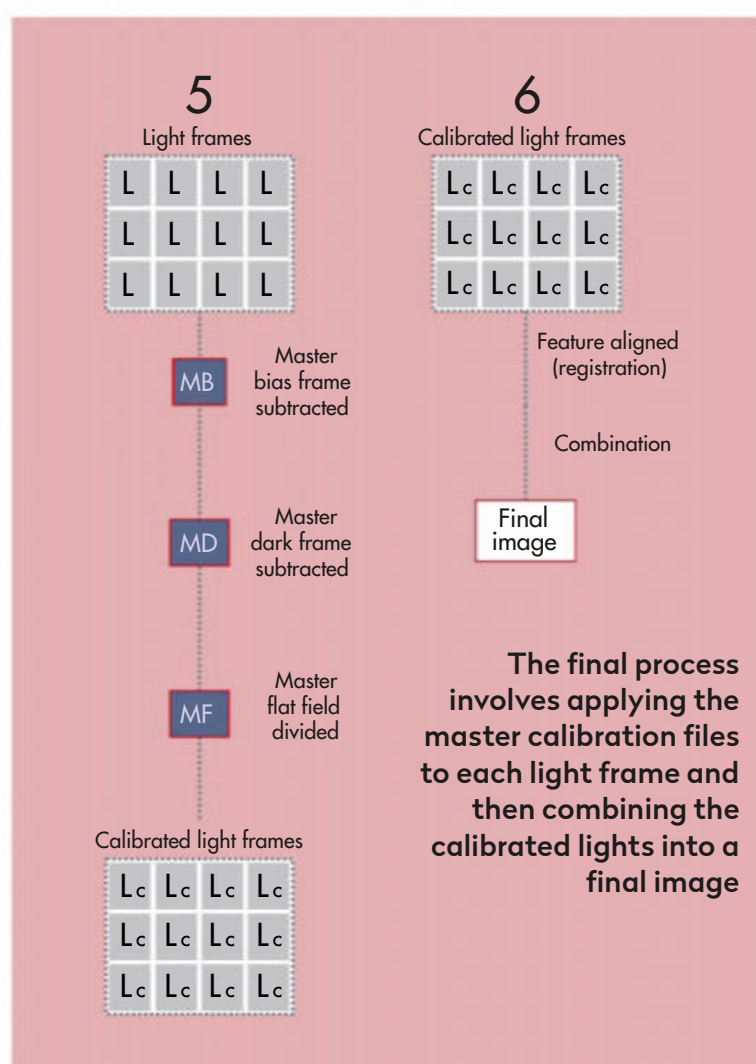
Basic calibration involves processes known as dark frame subtraction, flat-field correction and bias field correction. In addition, more advanced processes can be employed to apply some of these calibration processes to the calibration frames themselves before applying to the final image.

In imaging parlance, image frames are often referred to as 'light frames'. Images taken using the same settings but with the front of the camera covered are known as 'dark frames' or 'darks'. The data recorded by a dark frame is dependent on temperature, so it's important to take dark frames at a similar time to when you're collecting your light frames. Some astrophotographers choose to create a library of darks made at specific temperatures for this purpose. However, it's important to note that camera characteristics can change over time, so a library should be periodically updated.

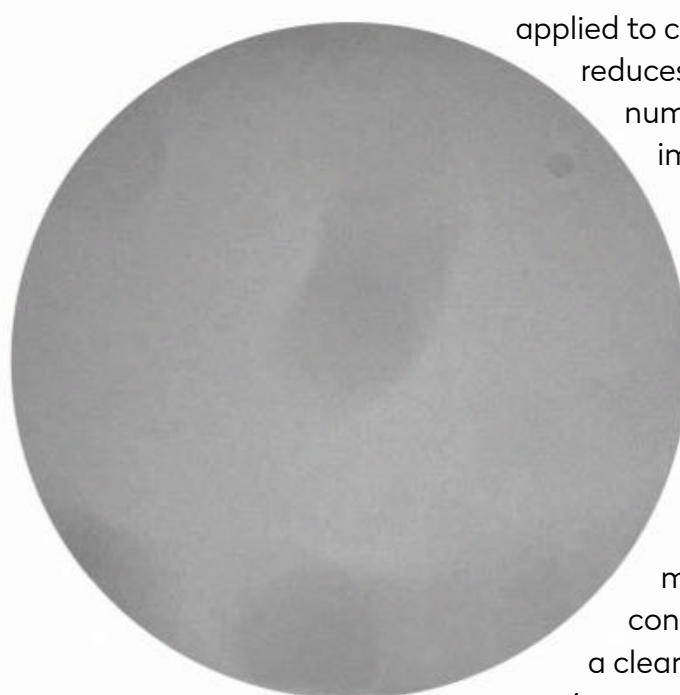
Every image has an element of random noise. This can be reduced by taking several light frames and averaging them together. A similar process can be



▲ Full calibration involves creating master bias, dark and flat frames, plus a set of dark flats – at the same exposure as flat field images but with the sensor covered – to further reduce noise in flat field frames



The final process involves applying the master calibration files to each light frame and then combining the calibrated lights into a final image



▲ A flat field image records aberrations such as dust on the sensor or lens so they can be isolated and removed

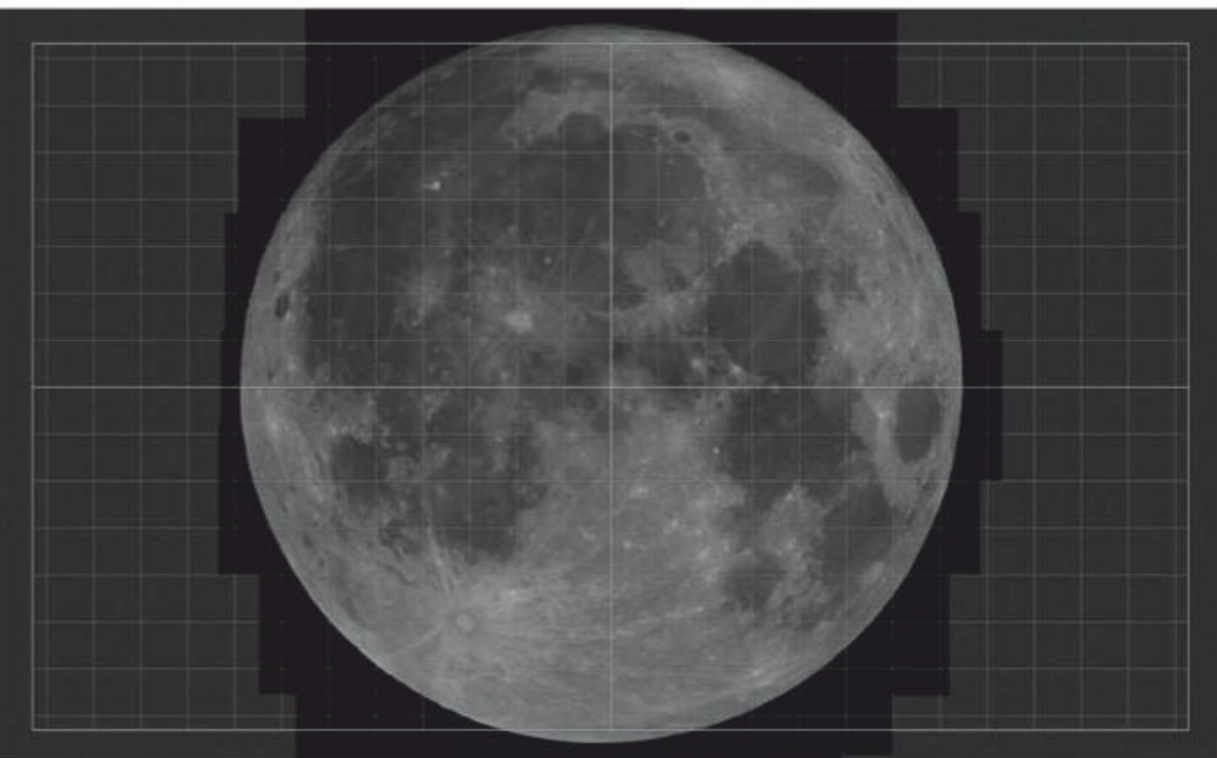
applied to calibration frames. Noise reduces by the square root of the number of images stacked: four images reduce the noise to half strength, nine reduce it to one-third strength.

Flat fields (flats) are taken through the same optical setup used to collect the light frames but with the instrument pointing at an evenly illuminated target. This may be a specially constructed light panel or even a clear, evenly lit sky. Typically, an image saturation of one-third to half the camera's full saturation is ideal.

Bias frames are the shortest exposures possible with the camera aperture covered. They represent the base state of the camera's pixels, which typically have small, non-zero values even when no image is present.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE



Imaging the largest full Moon of 2019

Big may be beautiful, but it also means challengingly bright

There's a common misconception that the best time to look at the Moon is when it's full. At this phase, the Moon is opposite the Sun in the sky and sunlight, as far as we're concerned on Earth, is falling straight down onto the lunar surface. As a result, there are no significant shadows and features such as mountains, crater walls and cracks blend into the bright surrounding regions.

In truth, the Moon is not quite opposite. If it were, it would be inside the Earth's shadow and eclipsed. Instead it will be slightly north or south of directly opposite the Sun in the sky. Nevertheless, at full Moon, lunar features are at their most ill defined. That doesn't prevent people wanting to image the full Moon, though, maybe because it's such an icon of the night sky, maybe for the Everest-like 'because it's there' challenge, or maybe to create colour-saturated images bringing out the mineral composition of the Moon. And with February's full Moon being the

▲ You could simply take a single shot with a DSLR, but with the Moon so bright you'll need a mosaic to truly capture the lunar surface's details



Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

largest of the year (see page 47), the opportunity to image it 'up close' may prove irresistible.

Imaging the full Moon can be done with a DSLR camera. A low ISO and fairly fast shutter speed are needed to avoid overexposure. Another way is to create a mosaic of the lunar surface using a setup that images only a small area at a time. Navigating across the full Moon's disc, however, is complicated by the lack of shadows to use as reference points.

A high-frame-rate camera setup is the best way to go: subsequent processing then gives you the sharpest possible result. Careful adjustment of the settings will allow you to optimise the appearance of the albedo features – areas of the lunar disc that stand out because they reflect a different amount of light.

The key to success is to orientate your camera so that moving your telescope in right ascension moves the Moon horizontally through the frame. Once this has been done, you need to decide on a technique that'll let you move methodically over the lunar surface in overlapping sections. A careful and alert eye is required to spot edge-of-frame features that will provide an anchor point for the next frame and row.

How many overlapping panes you capture depends on how large an image scale you use. If you're new to this, it's worth keeping the image scale low so you don't have too many panes to work with. We would suggest four to nine as a good starting point. If you're more experienced, the choice is yours, but the capture can get quite intense!

A good way to identify navigation points is to assign a meaning to them. For example, a crater rim and a bright spot might look like a smiling face. Silly though this seems, the more outlandish your choice of comparison, the more likely you are to remember the features when you move to the next area.

Once you have all your frames, the next step is to process them and stitch them together. In our step-by-step guide we look at using software to take the pain out of this process. 🌀

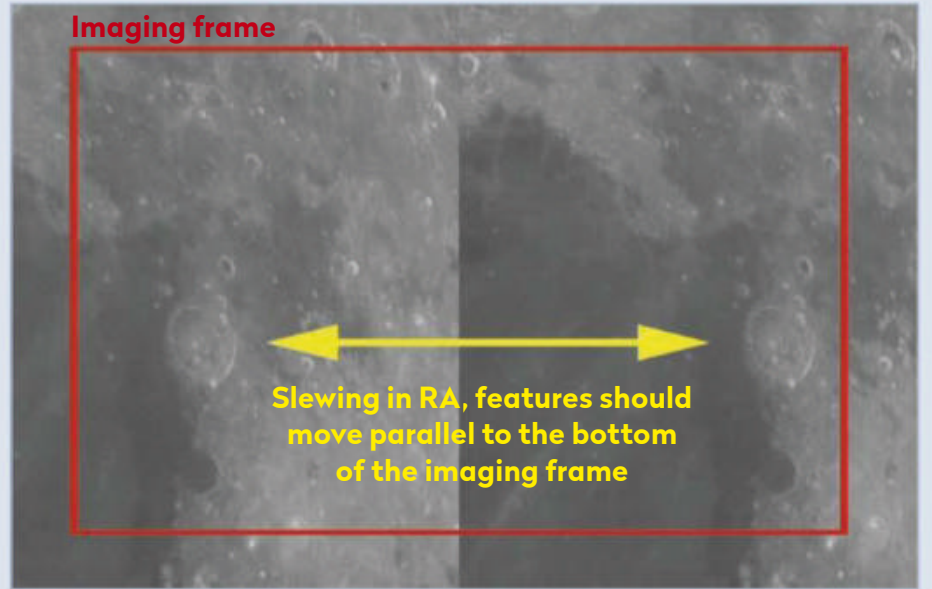
Recommended equipment: high-frame-rate camera; a telescope on an equatorial mount

✉ Send your images to:
gallery@skyatnightmagazine.com



STEP 1

The image scale can be altered with optical amplifiers such as Barlow lenses or Powermates. The image scale is the thing that determines how many panes need to be captured. Using a red or infrared pass filter will help stabilise the view and provide a sharper capture result.



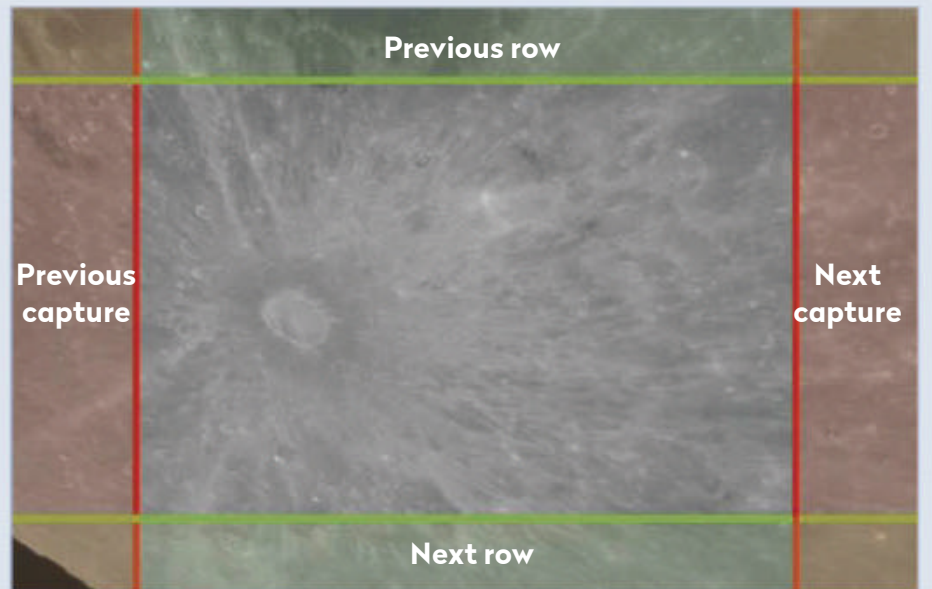
STEP 2

With the Moon in frame, slew in right ascension (RA). If the Moon's features appear to move at an angle to the bottom of the frame, carefully loosen the camera in the eyepiece holder and rotate it until the Moon's movement is parallel. Once done, don't forget to re-tighten the camera in the eyepiece holder.



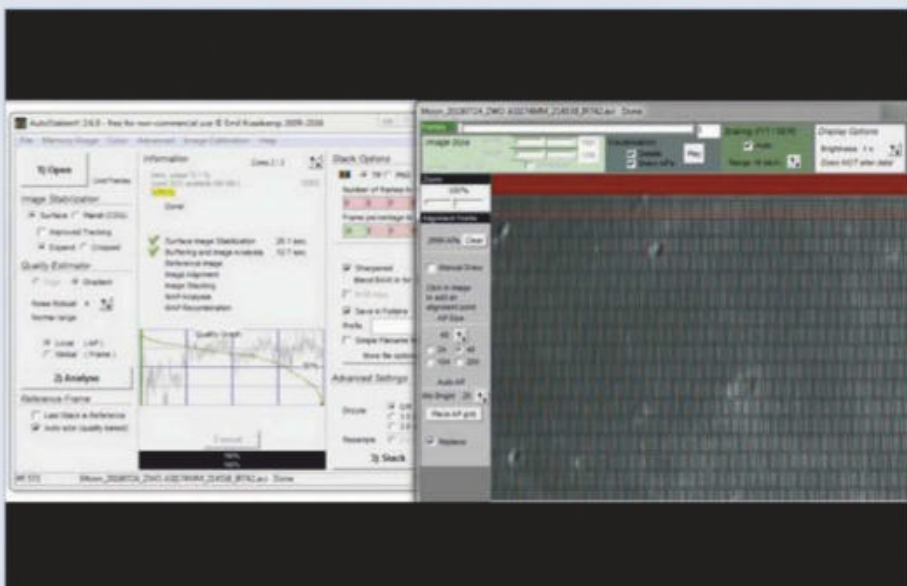
STEP 3

Focus accurately; the Moon's edge is a good target for this. Then, move your telescope so that a really bright feature, such as Tycho or Proclus, is in frame. Adjust exposure for a high frame rate and keep the gain below 50%. A small boost to your gamma setting can help bring out detail in the darker lunar



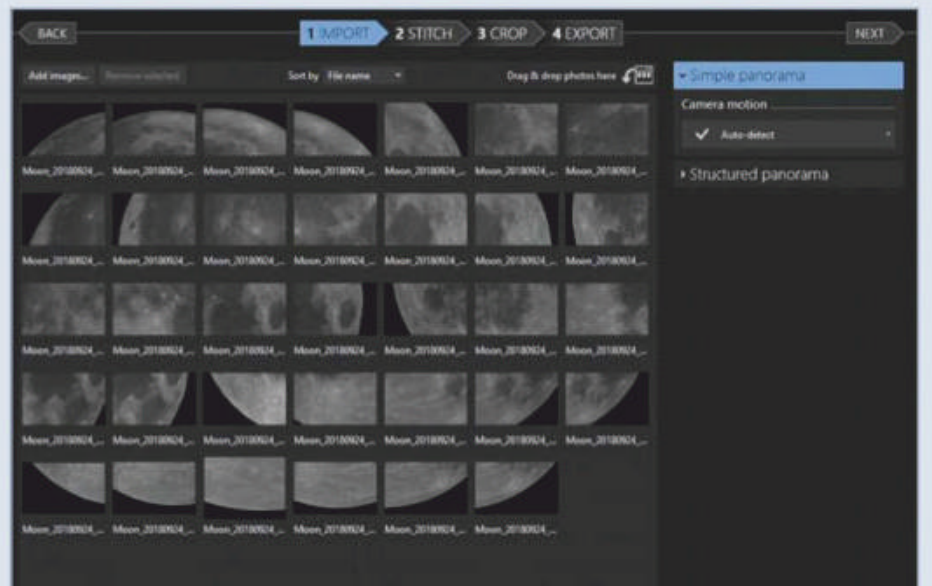
STEP 4

Start at the northern limb and work in rows, with a good overlap between frames. Once a row is complete, drop south in declination for the next one. Make a note of features at the edge of each frame as you go. If you doubt an overlap's integrity, don't be afraid to go back and redo a frame.



STEP 5

Programs such as AutoStakkert can be used to batch process your capture files. Simply drag all the captures into the main window and process the first result. Initially this can be as simple as clicking Analyse → Place AP Grid → Stack. Once done, all subsequent frames will be processed sequentially.



STEP 6

A program such as Microsoft's free Image Composition Editor (ICE) can take the sting out of building the mosaic. All you need to do is drag your processed images into ICE's main window and click 'Stitch'. Finally, 'Export' in a lossless format (eg PNG or TIFF), load into editing software and tweak as desired.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING



The final image, cropped and histogram-adjusted using the plug-in AstroFlat Pro

A software solution to missing darks and flats

Using the AstroFlat Pro plug-in to improve your images in the absence of key calibration frames

Astrophotography is a multi-layered process, from the initial capturing of the data and stacking of the images – known as ‘lights’ – through various image-processing stages to get to the final picture. The first stage of capturing those precious photons doesn’t just involve taking the lights, it should also involve taking flat, dark and bias frames for calibration. Flat frames are used for correcting uneven field illumination and smudges; dark frames are used for removing the dark signal from light frames; and bias frames help remove the camera sensor chip readout signal.

However, sometimes the weather intervenes, and while you may have captured your light frames, you may not always be able to get the flats or darks.



Astronomy writer and broadcaster **Paul Money** is reviews editor for *BBC Sky at Night Magazine*

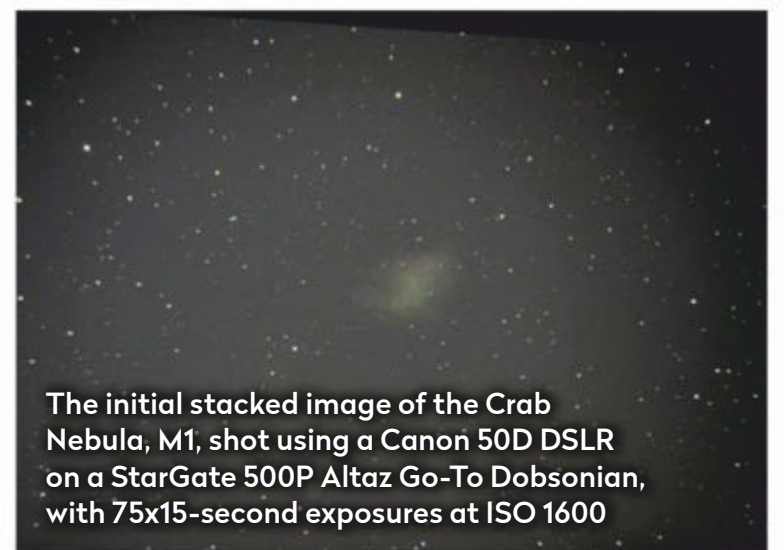
Some stacking programs do a good job at dealing with a lack of dark frames but without flat frames you may find you have a gradient across your image and some ‘noise’ – random variation of colour or brightness – that can spoil the final result.

One way of dealing with this is to use a plug-in, such as AstroFlat Pro, to flatten the luminance in your astro images. It costs little and works with Photoshop, PaintShop Pro and most image-processing programs that can use the Adobe Photoshop 8BF-style filter plug-in. Download and install it, and it will find your existing image-processing programs and ask if you want to add the plug-in to them. Once triggered from inside those programs, AstroFlat Pro works in a stand-alone mode until it’s finished its job, before returning the processed image back to the host program. In our case we used PaintShop Pro 2018, but the process is the same for Photoshop and there is online help for other programs available.

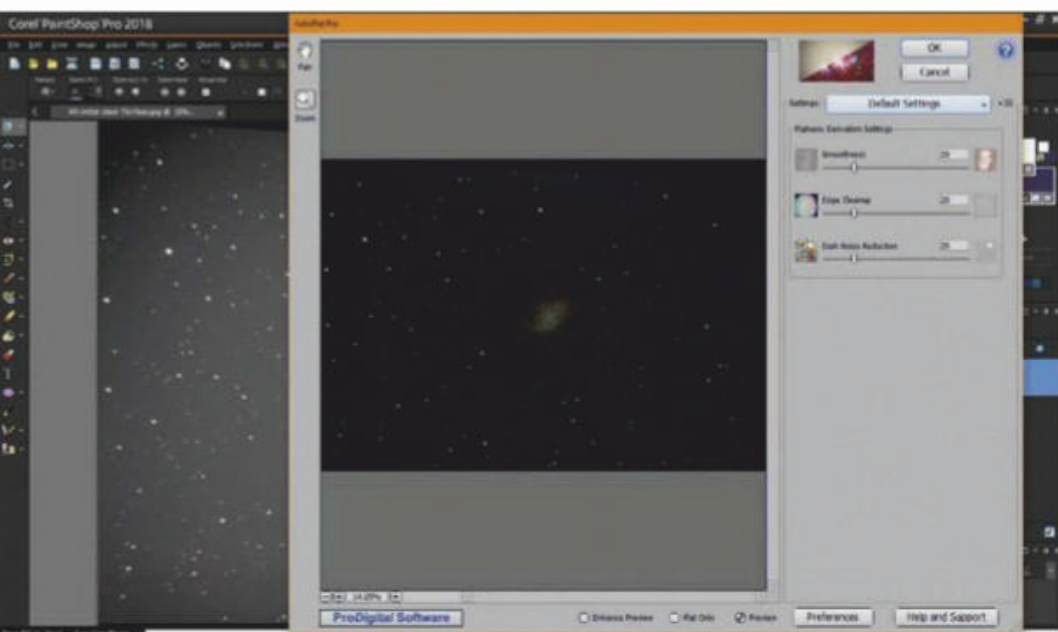
Tweak your settings

We begin with an image of the Crab Nebula, M1, taken with a StarGate 500P Altaz Go-To Dobsonian, which is a stack of 75x15-second exposures at ISO 1600 using a Canon 50D DSLR. This was stacked using Astro Pixel Processor and saved as a TIFF file.

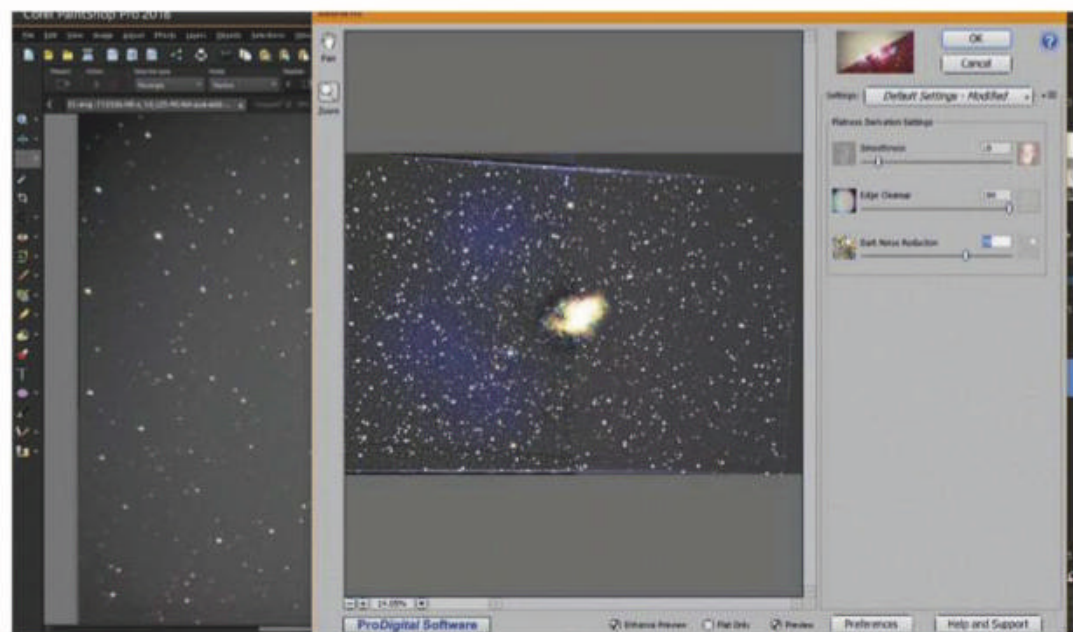
Open it in Photoshop or PS Pro as you normally would, then – in PS Pro 2018 – fire up the AstroFlat plug-in, by clicking on Effects > Plugins > ProDigitalSoftware > AstroFlat Pro. In Photoshop, substitute Effects with Filter and follow the submenus as outlined above.



The initial stacked image of the Crab Nebula, M1, shot using a Canon 50D DSLR on a StarGate 500P Altaz Go-To Dobsonian, with 75x15-second exposures at ISO 1600



▲ AstroFlat Pro's default settings, with Smoothness, Edge Cleanup and Dark Noise Reduction all set at 20



▲ An enhanced preview with the default settings applied on the left of the image and our chosen settings applied on the right

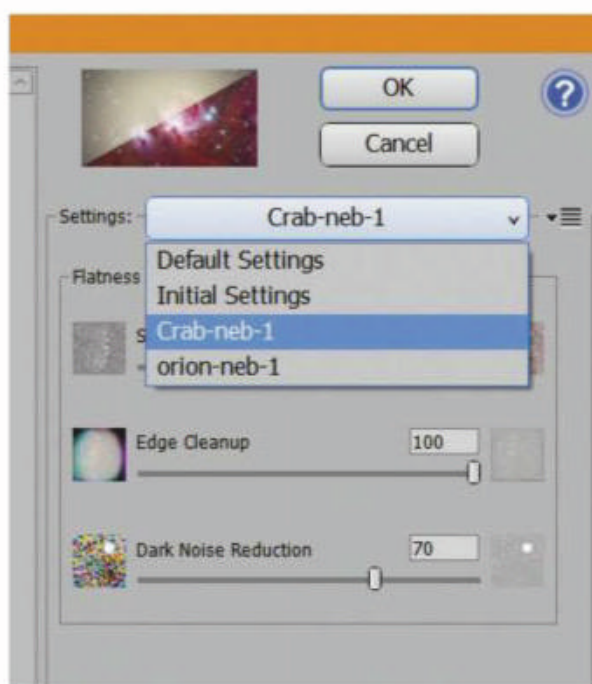
As AstroFlat Pro opens, it maps the luminosity across the image then displays the image with default settings which may or may not be ideal depending upon your image. To the upper right of the window there are three sliders that give you control over how much an effect is applied. These are 'Smoothness', 'Edge Cleanup' and 'Dark Noise Reduction' and their values range from zero to 100. Oddly, the 'Smoothness' setting *begins* at 100 – having no effect on the image – whereas the other two begin at zero. The default values (set at 20) are a good starting point, but naturally it depends on the initial image and you can adjust the sliders until you get the desired effect. Make sure that in the check box at the bottom 'Preview' is ticked so you can see the effects of the sliders in real time as you change them.

A close-up examination

With our M1 example image we found that setting Smoothness at 10, Edge at 100 and Noise at 70 gave us the best overall result. You can use the checkbox at the bottom called Enhance Preview to show a contrast stretched view – revealing any other noise that you might have missed. However, this only affects the live view and not the final resulting image. On the accompanying screenshot (top right) with 'Enhance Preview' ticked, the left-half of the processed image shows the default settings applied while the right half shows the settings we've used above.

Your chosen settings can be saved and set as your new defaults using the Settings menu, where you can also load any stored settings (such as our 'Crab-neb-1' in the image above right) or delete them as desired. The 'Preferences' button at the bottom enables you to choose the overall program colour theme, the size of the text and controls, and to change a couple of options for the preview view.

Once you are happy with the displayed result and you've saved your settings, click the OK button at the



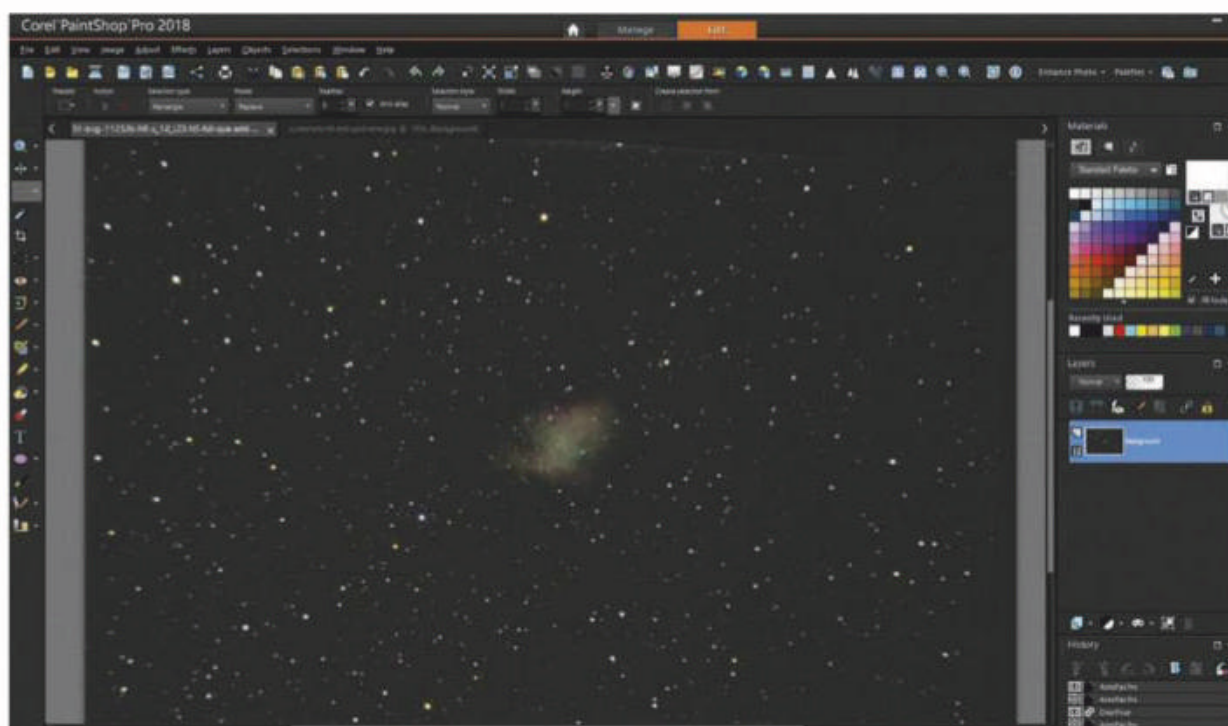
▲ Once you're satisfied with your settings, you can save and name them

top right. The program will apply the settings to the image, then close itself down and return you to your image-processing software.

AstroFlat can now be closed down and the settings applied to the image in the image-processing software. From here you can perform any further adjustments to bring out even more detail before cropping and saving your final masterpiece.

It is worth noting that AstroFlat Pro is not a full substitute for missing flat or dark frames, but it can certainly be a great help for salvaging images that may otherwise have been binned. The noise reduction helps take out any residual background noise while the 'Smoothness' function

really helps with vignette or gradients in an image. There is a small loss of detail, so it's a matter of choice as to when and how much processing should be applied, but we've found AstroFlat Pro very useful in our processing workflow. 🌌



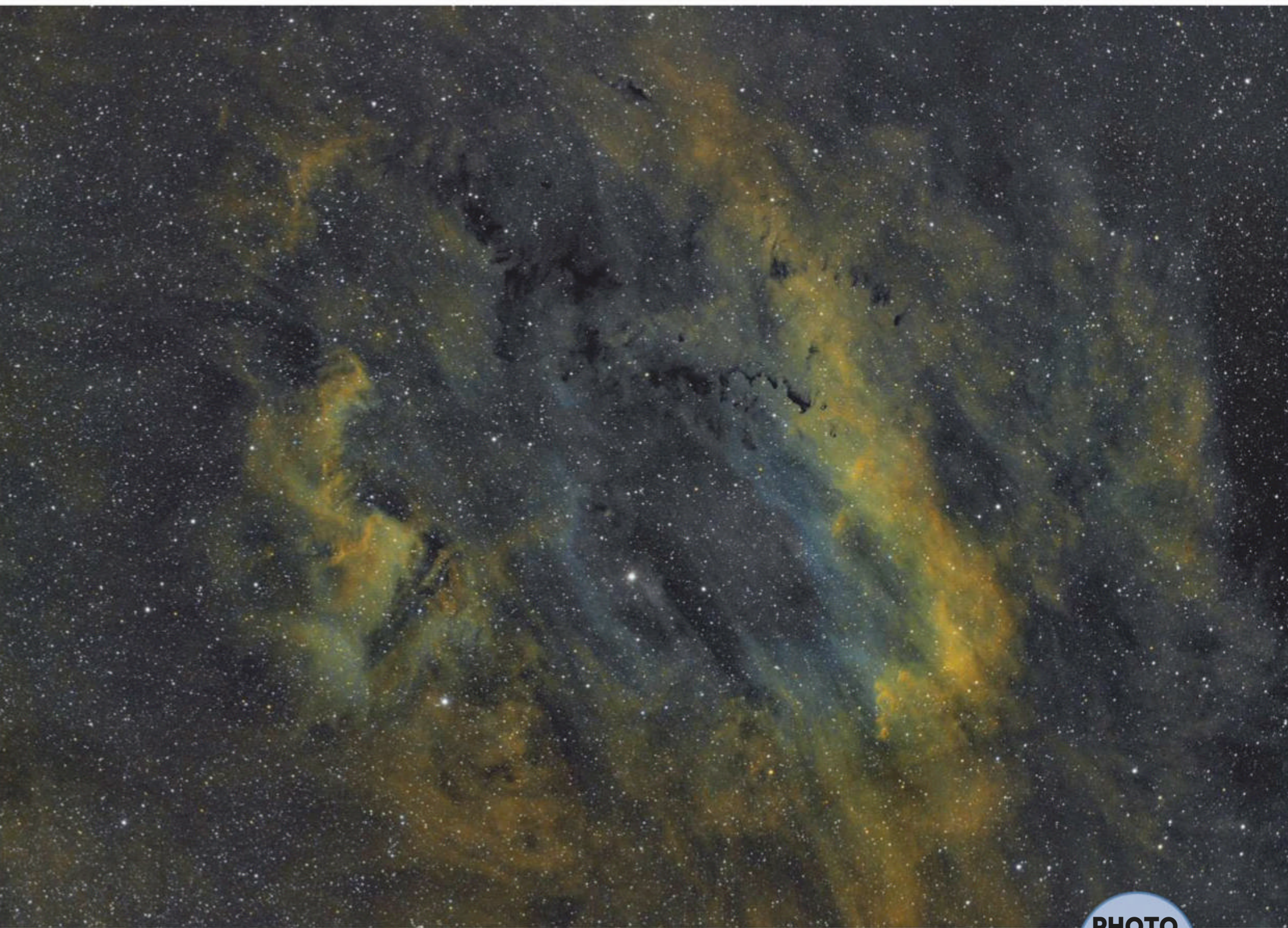
▲ Our M1 image back in the main image-processing software for final adjustments after we had finished manipulating it in AstroFlat Pro

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More
ONLINE

A gallery containing
these and more
of your images



△ Sharpless 119

Stewart Wilson, London, 26, 27, 28 September 2018



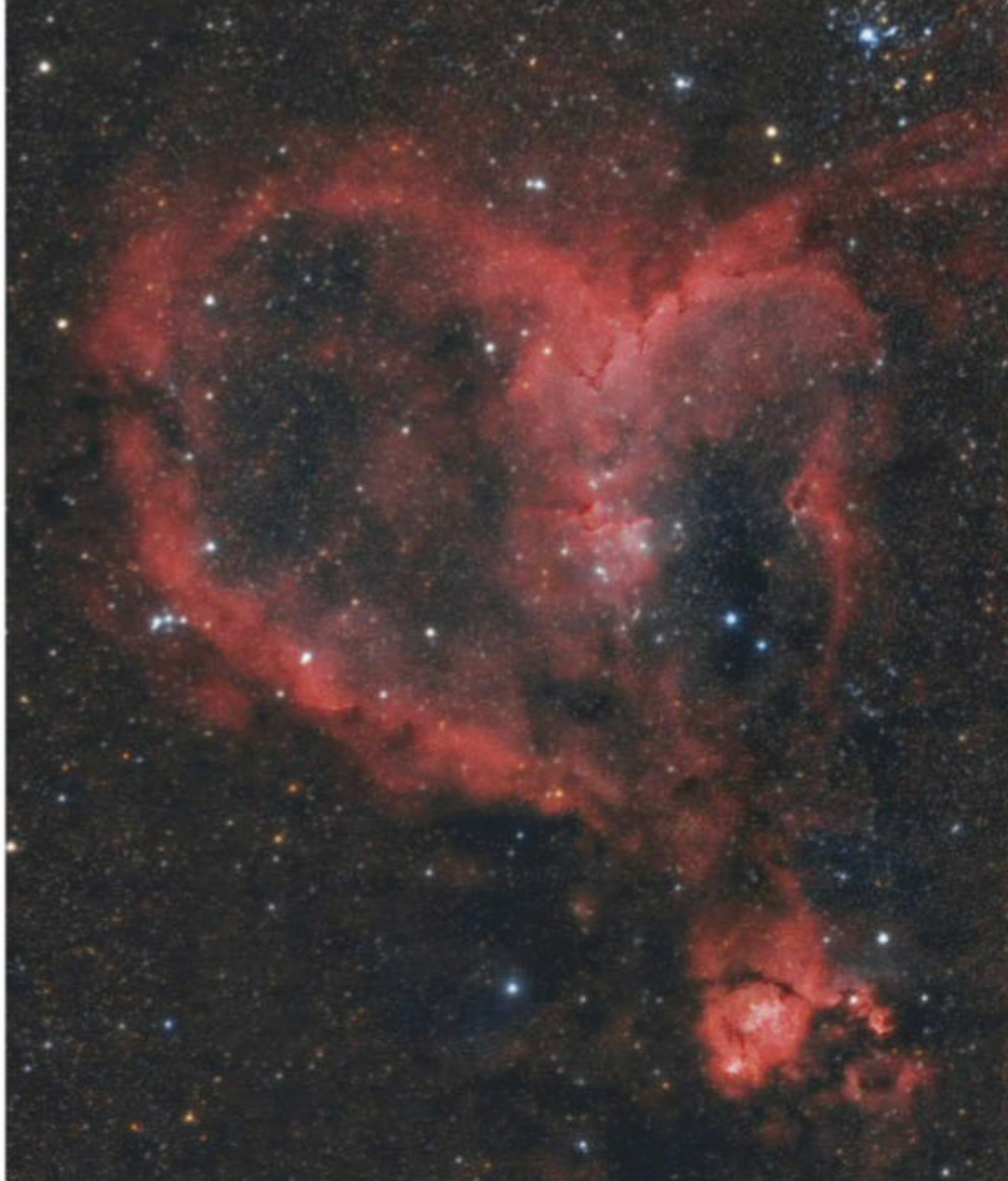
Stewart says: “I’ve been slowly working my way through the Sharpless catalogue looking for the larger and more interesting objects. This one caught my eye as I’ve not seen many photos of it, so I thought I’d give it a go.”

Equipment: ZWO ASI 1600MM-C mono camera, Takahashi FSQ-85ED apo refractor, Sky-Watcher HEQ5 Pro SynScan mount
Exposure: 40x600” Ha, 30x600” each SII and OIII
Software: Maxim DL, PixInsight

Stewart’s top tip: “At first it’s tempting to

shoot several targets in a night but try to resist. The more exposure time you can get on a target, the better your final image. I regularly spend 50 hours or more on targets over several nights, weeks or even months. It makes all the difference to the smoothness of the image and the ease of processing.”

**PHOTO
OF THE
MONTH**



△ The Heart Nebula

Tom Howard, Isle of Wight, 7 October 2018



Tom says: "The Heart Nebula is a favourite of my partner Christine. This is a busy section of sky so I experimented with several processing techniques to allow the nebula to shine through."

Equipment: Nikon D7000 DSLR camera, TS-Optics 65mm quadruplet apo refractor, Sky-Watcher AZ-EQ6 Go-To mount **Exposure:** 51x5' **Software:** DeepSkyStacker, Photoshop

▽ The Pleiades

Emil Andronic, Bushey, 23 October, 7 November 2018



Emil says: "Excited to see the Pleiades rising behind my house, I first shot it when the Moon was bright. I wasn't happy with the result so shot it again on a moonless night."

Equipment: Canon EOS 700D DSLR camera, TS-Optics 65mm quadruplet astrograph, Sky-Watcher EQ3 Pro SynScan mount **Exposure:** ISO 800, 10x600", 88x300" **Software:** DeepSkyStacker, Photoshop, Lightroom



Waxing gibbous Moon

Vicki Pink, Southampton, 17 November 2018



Vicki says: "It was a perfect night for imaging: everything went smoothly, conditions were great and no sign of dew. It was only the third time I'd used my camera after having some great help on my first try. After stacking and processing I was very happy with the clarity and focus of the image."

Equipment: Altair Astro GPCAM2 290C colour camera, Sky-Watcher Explorer 130P SynScan AZ Go-To Newtonian **Exposure:** SER video, 3.5', 100 frames **Software:** SharpCap, AutoStakkert! 2, RegiStax 6, GIMP





△ The Andromeda Galaxy

Nigel Arnold, York, 6 October 2018



Nigel says: "This was my second attempt at Andromeda. As soon as I saw the first unprocessed image in the EOS I was so excited about how it'd turn out."

Equipment: Canon EOS 5D Mk III DSLR camera, Sigma 150-600mm lens, Sky-Watcher HEQ5 Pro SynScan mount

Exposure: 33x120", 15 darks, 15 bias, 15 flats

Software: BackyardEOS, PixInsight

▷ The Ghost of Cassiopeia

Carl Gough, Littlehampton, 9 October 2018



Carl says: "I selected this after seeing a friend's narrowband version. He was unable to do an HaRGB version due to light pollution. As I live under Bortle scale 4 skies I decided to give the HaRGB version a go."

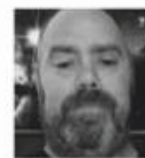
Equipment: ZWO ASI 1600MM-Pro mono camera, TS-Optics 80mm triplet apo refractor, Sky-Watcher HEQ5 Pro SynScan mount **Exposure:** 15x600" Ha, 15x120" each RGB **Software:** SGPro, PHD2, PixInsight





◀ The Triangulum Galaxy

Phillip Froggett, Hertfordshire,
11, 12 November 2018



Phillip says: "I've imaged this before with my DSLR and wanted to improve the quality now I'm using a CCD. It's my first image with a mono camera using RGB filters so a big learning curve from what I was used to with my old colour camera."

Equipment: Atik 383L+ mono CCD camera, Sky-Watcher Explorer 200P reflector, Sky-Watcher NEQ6 Pro Go-To mount

Exposure: 3x600" Ha, 8x600" each LRGB

Software: SGPro, PixInsight

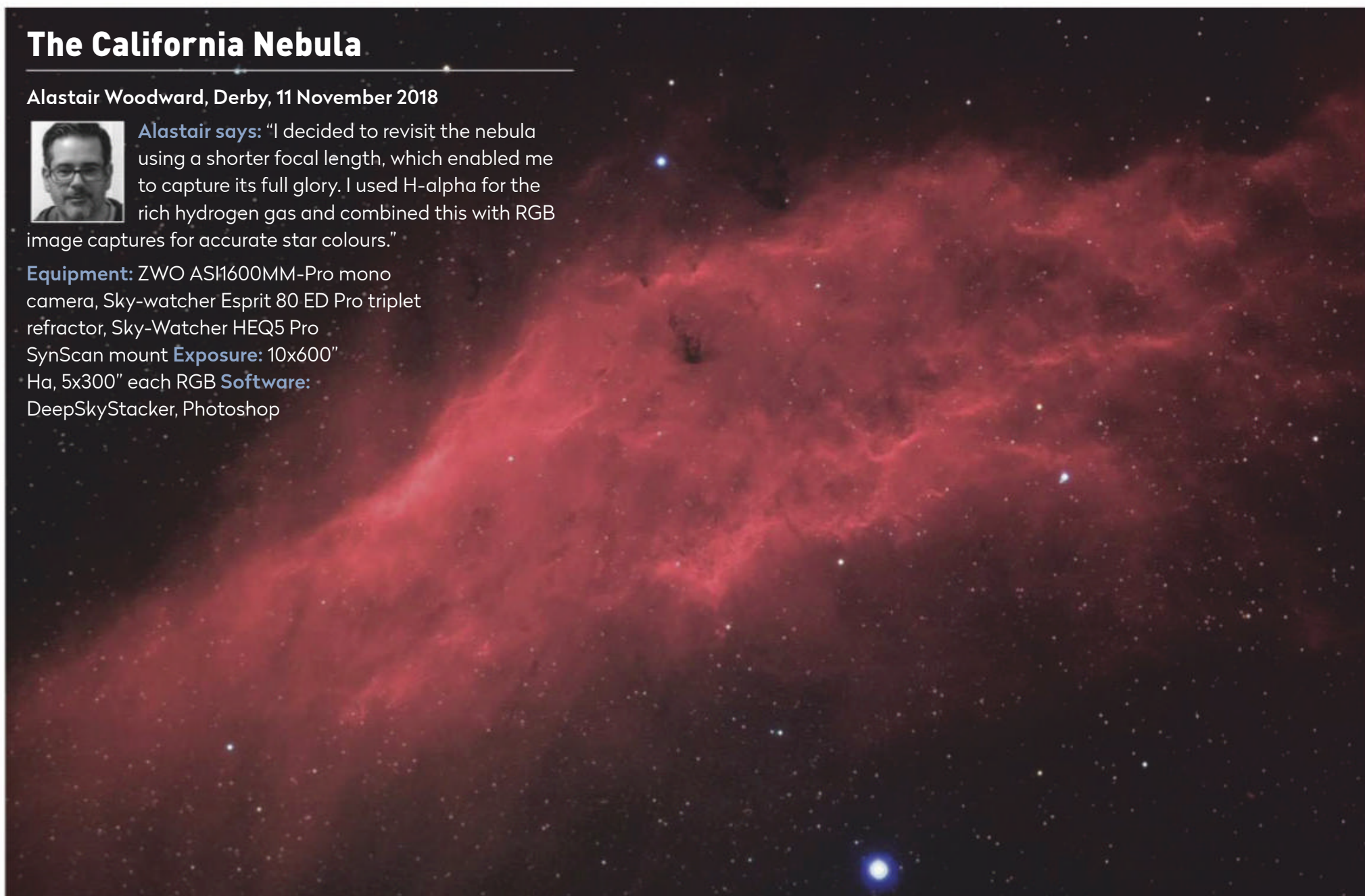
The California Nebula

Alastair Woodward, Derby, 11 November 2018



Alastair says: "I decided to revisit the nebula using a shorter focal length, which enabled me to capture its full glory. I used H-alpha for the rich hydrogen gas and combined this with RGB image captures for accurate star colours."

Equipment: ZWO ASI1600MM-Pro mono camera, Sky-watcher Esprit 80 ED Pro triplet refractor, Sky-Watcher HEQ5 Pro SynScan mount **Exposure:** 10x600" Ha, 5x300" each RGB **Software:** DeepSkyStacker, Photoshop



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DIY ASTRONOMY

Build a red light sketching pad

A home-made accessory for recording observations in the dark

An illuminated pad is a valuable tool for astronomers of all abilities looking for a sturdy and reliable piece of kit for recording notes and making sketches in dark locations. This month's project is a lightweight, home-built pad that serves this purpose well. Sketching in the dark requires a light source, but you need an additional hand to hold a torch, while a head torch is usually too bright. Instead, our illuminated pad provides a smooth surface for your paper and a gentle backlit red glow – just enough to illuminate your work while preserving your night vision.

Meteor watchers and planetary observers are among those who typically use printed templates. We have included a selection of basic templates, like the one pictured to the right, in the downloads section of the website for you to use. The red area of our pad is A5 sized and our templates fit neatly over it, but any paper can be trimmed to size so you can make your own sheets to suit your work. You can hold it in any orientation, as there is a border on each side.

Let it glow, let it glow, let it glow

The unit's light is generated by an electroluminescent (EL) panel. The material used in these thin sheets gives off light when stimulated by electricity and is



Build this month's project and you'll be able to read in the dark without ruining your night vision



Mark Parrish is a bespoke designer. See more of his work on his website: buttondesign.co.uk

commonly used in illuminated displays. The power can come from either a mains supply (which we don't recommend as you could be working in damp conditions), a 12V battery (like a PowerTank) or – as we chose – a battery pack with eight AA cells. A small 'inverter' is required to turn the 12V DC supply into a speedy AC current for the panel. Luckily no electronics skills are required and you can just plug the parts together. Make sure you select the correct kit for the power supply you want to use.

Everything is housed in a simple wooden case. We have provided plans online, designed around the kit we bought, but if your inverter is a bit thicker than ours (29mm high) you might need to adapt the walls and dividers. The EL panel isn't tough enough to write on so a clear screen needs to be added to the top of the case. This is made from thin plastic you can find in most DIY stores. Next, mask off and spray the back black to conceal the internal parts. The layer below the screen and the base panels are made from 3mm plywood but if you have to buy a big piece of the plastic you could use it for these layers as well.

Use two strips of the plastic to make clips for the paper. After shaping and drilling them you can heat the ends with a hot air gun to introduce a little bend. Think about customising your pad – you can add a pencil holder or carrying strap. However you finish your pad, we hope you enjoy seeing red. 🌌

Tools and materials

- ▶ A coping saw, a tenon saw or similar, drill and bits for screws and internal cabling (4mm and 10mm), small screwdriver, craft knife, clamps and glue gun (optional).
- ▶ Good quality plywood or MDF (3mm thick, about A3 size). Small sheet of clear plastic (approx 2mm thick). About 1,800mm length of softwood approx 12mm thick x 30mm wide.
- ▶ Sundries include a red A5 electroluminescent (EL) panel kit, 12 wood screws (3.5mm x 25mm), two M4 washers, masking tape, wood glue and a bit of sponge foam (a washing-up sponge will do).
- ▶ For the finish you will need some black spray paint for the screen and optional paint (any colour) for the main case.

More ONLINE
Download plans, diagrams and more photos for this project. See page 5 for instructions

Step-by-step



Step 1

Print out the downloadable plans and use them to mark out the plywood and plastic sections before cutting them out. First cut the walls and dividers from softwood strips. A cable access hole needs to be drilled through each divider.



Step 2

Cut out a rectangular hole in the plywood layer to suit the EL panel. Allow a gap at each end for the tabs and cables. Drilling a hole at each corner makes it easier to turn the corner with the coping saw.



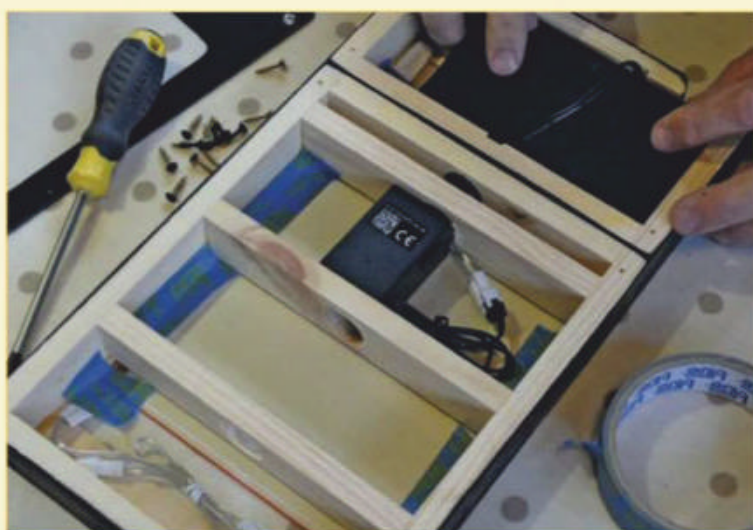
Step 3

After checking that the battery case and inverter fit inside, use wood glue to join the walls and dividers to the plywood panel layer. We went a bit overkill with the clamps – you can tape it together while the glue dries if you don't have clamps.



Step 4

Cover the back of the clear plastic screen with masking tape. Mark out the position of the illuminated part of the EL panel then gently cut round with a scalpel or craft knife. Next, peel off the outside then spray with black paint.



Step 5

After painting the case, add the electronic parts. Check these work before using tape on the back of the EL panel to hold them in position. We used some glue gun blobs to secure the inverter and wedged sponge foam next to the battery pack.



Step 6

Make two clips from offcuts of the plastic and secure these and the plastic screen using small wood screws and washers, being careful not to over tighten them as the plastic can crack. Add the back panel and battery access panel to the back.

**SPECIAL
EDITION**



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REVIEWS

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86

Portable, practical and
a punchy performer – it's the
new Celestron Advanced
VX 9.25-inch telescope



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★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

Our experts tell you what they think of the latest kit

FIRST LIGHT

Celestron Advanced VX 9.25-inch Schmidt-Cassegrain telescope

A portable, easy to set up mount and scope package for both novices and experts

WORDS: PETE LAWRENCE

VITAL STATS

- **Price** £2,299
- **Optics** Schmidt-Cassegrain design
- **Aperture** 9.25-inch (235mm)
- **Focal length** 2,350mm (f/10)
- **Mount** Advanced VX equatorial, load capacity 13.5kg (30 lbs)
- **Weight** Equatorial head 7.71kg (17 lbs), tripod 8.16kg (18lbs), supplied counterweight 5.4kg (12 lbs)
- **Supplier** David Hinds Ltd
- **Tel** 01525 852696
- **www.celestron.uk.com**

The Celestron Advanced VX mount and C9.25 telescope make for an impressive setup that packs a punch in terms of viewing potential. Easy to transport and straightforward to assemble, the C9.25's 9.25-inch (235mm) aperture is generous, gathering a third more light than an 8-inch (200mm) reflector. Its f/10 optics put it in the slow category and, in theory at least, it is best suited for Solar System objects. However, if your interest is deep sky, it's no slouch on that front either.

On our first night out, we couldn't resist a peek at an old friend, the Orion Nebula, M42. Using the supplied 24mm eyepiece gave us 98x magnification. The nebula's bright core practically filled the view, bumpy, mottled and full of detail. At its heart, the main stars of the Trapezium cluster were beautifully split.

To be fair, the central portion of M42 is an easy target. Less so the dimming tendrils of glowing gas that arc away from it. Through the VX they were fascinating to follow and extended for quite some distance. We also liked the view of M42's fainter neighbour, De Mairan's Nebula, M43. Its classic comma shape was easy to see thanks to the contrast delivered by the C9.25's Starbright/XLT-coated optics.

Focusing on the details

Switching to the Moon, the view was exquisitely sharp. The 5km-wide Rima Ariadaeus appeared like a scratch across the lunar surface and we were really impressed with the intricate detail in the central mountains of the 101km crater Theophilus. Turning the view to a rather tiny Mars, its colour, disc and phase were very evident. Despite poor seeing conditions, we could clearly see one of its polar caps and evidence of surface markings.

The AVX mount appears well matched to this size of telescope, providing a solid, yet highly functional

platform. The mount head is mostly of metal construction but with some plastic covers. It's easy to carry and we found it was straightforward to set up. This makes for a very portable system.

Assembly is quick and lifting the C9.25 onto the mount head is no trouble thanks to the light weight of the optical tube, which is fitted with a carrying ►

A scope with scope



The C9.25 telescope is a lovely mid-sized instrument. Its folded optics and aluminium tube make it very light and portable. With a theoretical limiting visual magnitude of +14.4, its native 2.35m focal length also gets you up close and personal without too much effort. The views were bright and high contrast with lunar shadows inky black against a brilliant landscape. Planetary detail was good as was the view of extended deep-sky objects.

Without doubt this is a great all-round scope.

Focusing was positive with little mirror shift noted. The provided 6x30 finder felt a little puny but was adequate for most tasks.

Collimation is carried out by adjusting three hex bolts on the external secondary housing. The scope is also Fastar (Hyperstar) compatible: by using an optional lens assembly in place of the secondary mirror it can be converted from a slow f/10 telescope to a fast f/2 system. This gathers light 25x faster than in its f/10 configuration, making it ideal for deep-sky imaging.



See an interactive 360° model of this scope at www.skyatnightmagazine.com/celestronVX



Equatorial mount head

The equatorial mount head is relatively light, well-designed and very stable when used with the C9.25 telescope. It has large and easy-to-access altitude and azimuth knobs that can be used in conjunction with the internal 'all-star polar alignment' routine. The mount's computer has permanently programmable periodic error correction for improved tracking and features an internal real-time clock.

Tripod

The AVX mount head fits on top of a sturdy, adjustable tripod. The tripod's height can be varied from a minimum of 1,118mm to a maximum of 1,626mm.

It is lightweight, easy to carry and quick to deploy. Simple eyepiece holders are cut into the spreader bar and there's a plastic clip-on holder for the NexStar+ handset.

Control panel

The control panel provides connection ports for various mount functions. At the top of the panel is the port that connects to the mount's declination motor. One port provides connection for the NexStar+ handset, another for the connection of auxiliary devices such as an optional GPS. The final port is provided for autoguiding connections.

Motors and bearings

This latest incarnation of the AVX mount uses new, higher-torque motors, which offer improved tracking performance. They are described as being able to overcome slight balance issues. This is a good thing because the mount bearings aren't completely free-running and this can make finely tuned balancing tricky to achieve.

FIRST LIGHT

- KIT TO ADD**
 1. Celestron PowerTank Lithium
 2. Celestron StarSense Auto Align
 3. SkyPortal Wi-Fi Module

► handle. The scope-to-mount coupling is via a long Vixen dovetail on the optical tube. Once mounted, however, balancing the tube felt a little imprecise owing to the stiffness of the mount's bearings.

Alignment

The AVX mount's electronics provide many tweaking options

to improve tracking performance. This includes functions to calibrate the RA drive and store permanent periodic error correction. There are also numerous ways to align the mount for Go-To and tracking operations. Performing a rough polar align followed by a two-star alignment routine was very quick. Our Go-To experience after this was adequate with the scope pointing close to where it was supposed to be most of the time. After adding a further calibration star then running a simple 'all-star polar alignment' routine, we found our targets centred in the field-of-view each time. We slewed the scope around the sky a number of times to try and catch it out, but each time the target appeared properly centred. This was impressive given how quick the initial alignment routines were to complete.

The handset provides an interface to the AVX's 40,000 object Go-To database. 200 entries here have enhanced information and there's provision for up to 100 user-defined objects. The handset also provides for more basic operations, such as manual slewing. Nine slew speeds are provided, the peak rate moving the scope at 4° per second.

This latest version of the AVX mount has a number of improvements over previous versions, including new motors with increased torque. These give improved tracking and provide more power to overcome slightly unbalanced setups. The mount also has larger base castings which provide greater stability when using heavier loads.

Suitable for novice and experienced astronomers, the system's portability and ease of setup are great if you're in a hurry to get going, while the excellent optics of the C9.25 don't disappoint. Look after it well and it will provide a lifetime of astronomical enjoyment. 🌌



NexStar+ handset

The NexStar+ handset provides an interface to the AVX mount's computer. It's simple to use and displays information via a four-line, 18-character illuminated LCD display. Elegant design gives easy access to the 40,000 objects in the AVX's Go-To database as well as providing a simple-to-use directional control cluster.



VERDICT

Build and design	★★★★★
Ease of use	★★★★★
Features	★★★★★
Go-To/tracking accuracy	★★★★★
Optics	★★★★★
OVERALL	★★★★★

ALL PICTURES: WWW.THESECRETSTUDIO.NET

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Our experts tell you what they think of the latest kit

FIRST LIGHT

ToupTek G3M-224-C colour camera

A small, high-speed all-rounder that proves ideal for Solar System imaging

WORDS: TIM JARDINE

VITAL STATS

- **Price** £269
- **Sensor** Sony IMX224 colour 1.2MP
- **Sensor size** 4.8mm x 3.6mm
- **Bit depth** 8-/12-bit
- **Max resolution** 1,280 x 960
- **Max frame rate at full resolution** 150 fps
- **ROI support** Yes
- **Size** 72mm x 36mm
- **Weight** 66g
- **Supplier** Omegon
- **www.omegon.eu**
- **Tel** 0203 8688042

WWW.THESCREETSTUDIO.NET X 4, TIM JARDINE X 2

Good things come in small packages, or so the saying goes. The new G3M-224-C camera from Chinese company ToupTek certainly has a diminutive presence – it is roughly the size of a small eyepiece – so we were keen to discover what good things this keenly priced camera could produce.

Although passable as a multi-purpose camera for use on a range of both Solar System and deep-sky objects, the G3M-224-C is especially suited for planetary and lunar photography. As such it is ideally matched with long focal-length telescopes. To counter the issue of the exaggerated atmospheric blurring that usually accompanies high-resolution planetary imaging, a camera needs to have the ability to capture very short exposures – and lots of them – in a short time frame. That's something ToupTek's little camera does very well indeed. Once a few thousand images have been captured in a video file, you can use software to pick out the sharpest frames for you and combine them.

High-speed action

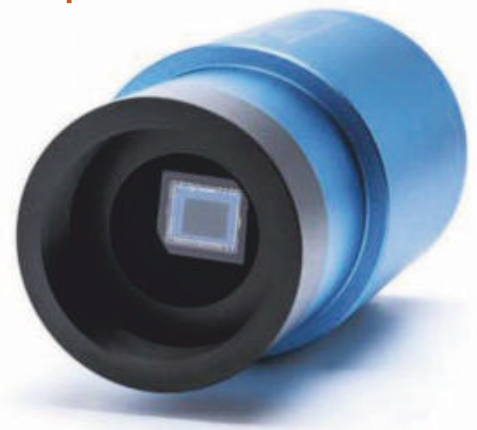
At full resolution the G3M-224-C was firing images out at 150 frames per second (fps), in 8-bit mode, and if a smaller 640x480 region of interest (ROI) was chosen, that rate soared to 287fps. Increasing the range of the camera to 12-bit mode reduced the frame rate considerably, but it was still able to throw out full-frame images at 62fps, and managed 120fps at 640x480.

With data being transferred at these speeds, having a reasonably capable USB 3.0 computer and a quick hard drive (with plenty of available space) is essential. It is quite mesmerising to see 10,000 individual frames captured within a minute, but as

the frame count goes up, so does the file size, which can greatly increase post-processing time.

We discovered a very attractive feature of the camera during an evening with clear patches between clouds. With minimal set-up time the camera was ready to work as soon as the telescope was pointed at Mars, and we made the most of the ▶

A superior sensor



At the heart of this little camera is a sensor from Sony that incorporates the latest advances to achieve better image quality in dark settings. The IMX 224 is a CMOS sensor with STARVIS technology, developed for surveillance cameras operating in low light, which therefore also makes it very attractive for astronomical cameras.

With square 3.75 micron pixels, the 4.8mm x 3.6mm chip yields images at 1.2MP in size, and with useful exposure times starting at 66 microseconds and upwards. We found that

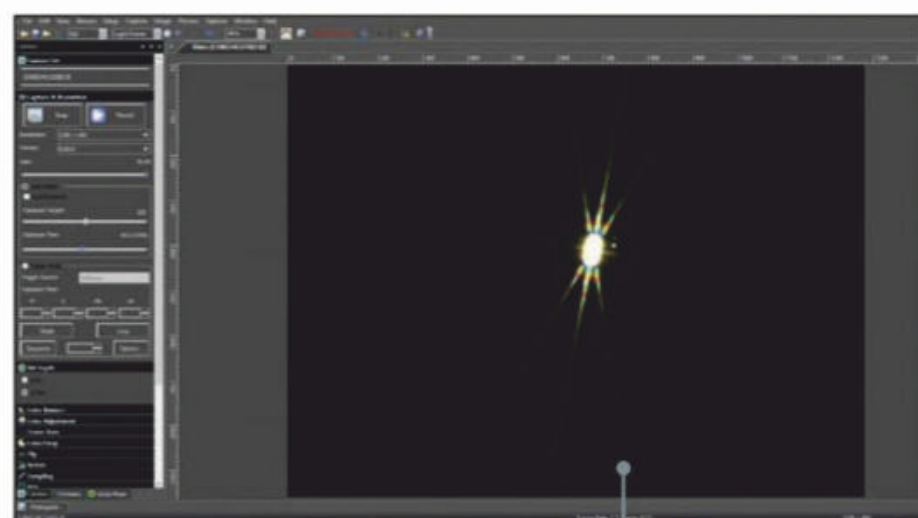
exposures between 30 seconds and one minute produced the most pleasing results for deep-sky images. But with the all-important need for speed on planetary targets we chose the lowest exposure time that would still yield a bright enough planetary image: a fine balance that is intuitively achieved using control sliders in the software. The ability to 'see' and record faint details with very short exposures makes the Sony IMX224 an excellent sensor choice for this planetary performer.

See an interactive 360° model of this camera at www.skyatnightmagazine.com/G3M224C



Size and power

Measuring just over 7cm in length, and with a maximum diameter of 3.6cm, the C-mount nose of the camera fits neatly into 1.25-inch fittings. One extension piece is included in the box, and screws on just in front of the infrared and ultraviolet anti-reflection window. As there is no active cooling system, no extra power supply is required.



Guidance software

Fully ASCOM-compatible for your preferred software, the G3M-224-C works with the latest development version of PHD2 – the popular guiding software for tracking stars. Simply select the 'ToupTek camera' option from the menu and adjust the settings to optimise the camera for auto-guiding use, perhaps as a stand-in for a main guide camera.

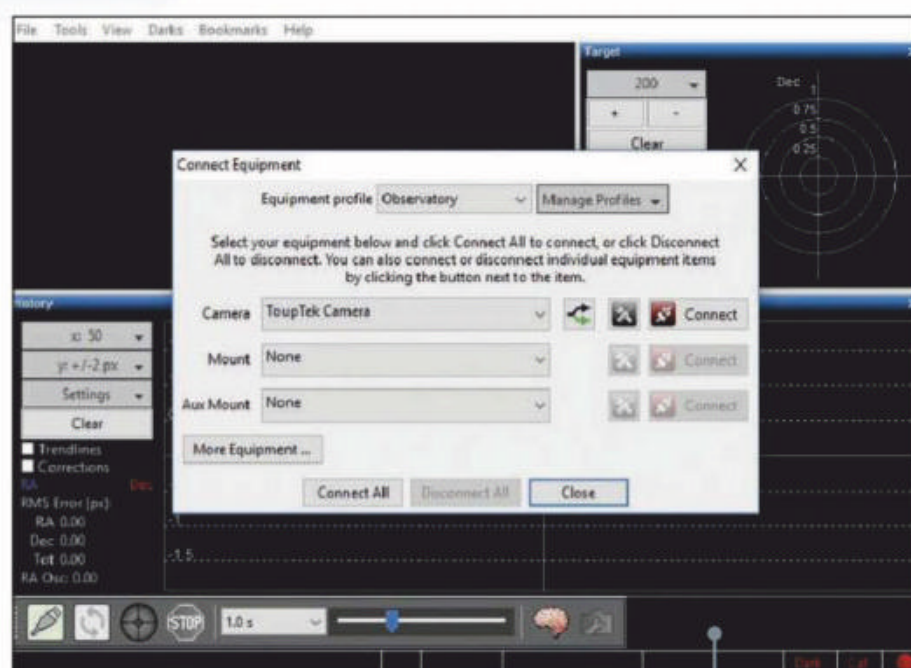


Image control

A software CD is included in the package, with very capable ToupSky imaging software. The program is easy to use and has a range of adjustments and features that enhance the camera for each particular target. The live view mode makes it easy to manually focus your telescope.

FIRST LIGHT

► The Moon taken with a Pentax 75 telescope, camera set at a gain of 1 and exposure of 2.212ms; best 18 per cent of 500 frames



Quick data transfer

Fast transfer of data between a camera and computer is a must for planetary photography, especially for targets where minimal rotation effects are desirable – such as Jupiter. Supplied with a good quality, 1.5m USB 3.0 cable, the G3M-224-C is optimised for the speedy shuttling of images and video files from the camera to a hard drive.



▲ Mars taken with a C11 telescope and 2x Barlow, best 10 per cent of 10,000 frames taken at 175fps in 12 bit mode

► Mars taken with a Pentax 75 telescope, camera set at a gain of 1, 17x45 sec exposures stacked for the final image



Linking to a telescope

Another useful facet of the camera is its ability to link directly to a telescope mount using the ST4 guide port on the rear, via the supplied cable. Although a computer is required to run your preferred autoguiding software, the output from the camera goes right to the mount, adjusting its position accordingly.



► camera speed to take image sequences between the clouds. The camera's almost 'grab and go' capability really helps work around varying weather patterns.

Our own observatory is set up with USB 2.0 connections, and although the Touptek camera is fully compatible, there is an associated drop in frame rates. However, we still managed 52fps with a selected ROI on Mars. Sadly, there wasn't much planetary action to be enjoyed during our test period – the poorly placed Red Planet being the only possible candidate – but we did manage some sessions on an obliging Moon, where the simplicity and speed of capturing the video files was impressive.

Turning the G3M-224-C towards deep-sky objects produced some variable results. By lowering the gain and increasing the exposure it was possible to capture deep-sky objects like those on the Messier list, but this is really more suited to a smaller, short-focal-length telescope. Although image 'noise control' – to counter random variation of colour or brightness – is very good, you do get some glow around the edges and corners, which starts to extend into the image as

exposure times increase. Brighter objects more easily captured with shorter exposures could be reasonable targets, but really the G3M-224-C should be viewed as a Solar System camera first and foremost.

It's worth noting that the G3M-224-C doesn't come with a fitted blocking filter for infrared and ultraviolet light. You will almost certainly need one for most targets. As a colour camera the Touptek captures everything you need in each exposure, so it's possible to adjust the colour balance of the camera within the software, which removes the slight greenish cast that may appear.

As a simple to use, fast and effective planetary camera, the Touptek demonstrates that good things can indeed come in small packages. 🌌

KIT TO ADD

1. Omegon infrared band elimination filter
2. Omegon Microspeed guidescope, 60mm
3. Omegon 5-in-1 optics cleaning set

VERDICT

Build and design	★★★★★
Connectivity	★★★★★
Ease of use	★★★★★
Features	★★★★★
Imaging quality	★★★★★
OVERALL	★★★★★

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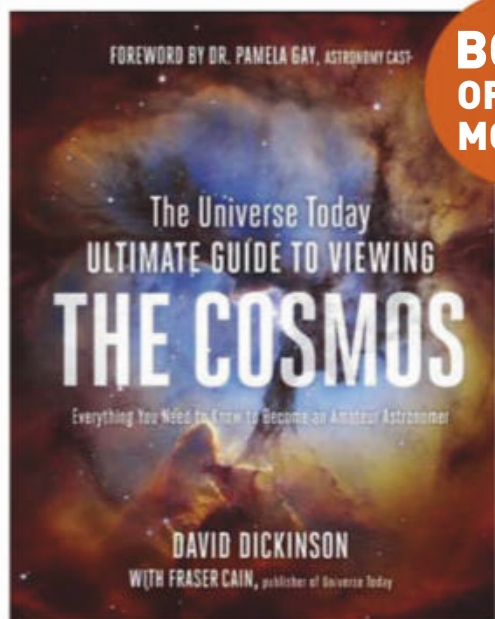
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New astronomy and space titles reviewed

BOOKS



BOOK
OF THE
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Ultimate Guide to Viewing the Cosmos

David Dickinson, Fraser Cain
Page Street Publishing
£21.29 • HB

For beginners, observing and making sense of the night sky is a painstaking task. Walking outside and gazing upward, it is easy to be overwhelmed by its grandeur and bewildering magnitude. Author and educator David Dickinson and *Universe Today* website founder Fraser Cain, though, are here to ease you into the subject, providing a complex but highly readable guide for amateurs (or even veterans who need a bit of a refresher), introducing the night sky and the tools needed to observe it.

With the guiding hand of a teacher they introduce us to stargazing, leading us away from the hectic, humdrum pace of our everyday lives. They outline the transition from daylight to dusk, its

physiological effect on our 'dark-adapting' senses and point out what we might see first – perhaps the Moon, maybe a meteor or hints of aurorae – before drawing us deeper into how we measure celestial distance, how far our eyes can actually see and the limits imposed by the bulk of atmospheric gases above our heads.

Dickinson and Cain discuss software and equipment to aid our understanding, braving the minefield of choosing the right telescope, the right aperture, the right mount and the right eyepiece. They show us how to build a basic Newtonian refracting 'scope for under \$50. We are schooled not only in observing cosmic objects, but also in sketching them: from dazzling Venus to Mars's crystal-white polar caps and from tiger-striped Jupiter to ring-girdled Saturn. Slowly with growing anticipation, we are transformed into gravity-shackled predators stalking celestial prey.

The authors remind us of our current good fortune, with more knowledge and awareness of Earth's 'cosmic address' at our fingertips than ever before, and greater access to a hobby that was

hitherto the preserve only of a rich elite. They show us how to track satellites,

identify comets, observe meteor showers, follow solar activity and time lunar occultations.

All in all, this book is a companion for any astronomer at any level of competency, but its authors' main message is that – aside from the science and the technology – we should not forget to simply revel in astronomy for the awe-inspiring

experience that it is.

★★★★★

Ben Evans is the author of several books on human spaceflight



▲ With this book you won't feel small and insignificant looking at the sky

Interview with the author David Dickinson



What advice would you give to novices?

Learn how to find your way around the constellations, the motion of the Moon and planets and how seasonal motion changes the view. You may be happy with that, or it may inspire you to get a telescope or try astrophotography. There's always something new to learn, from chasing comets to tracking satellites to following features on the Sun and more.

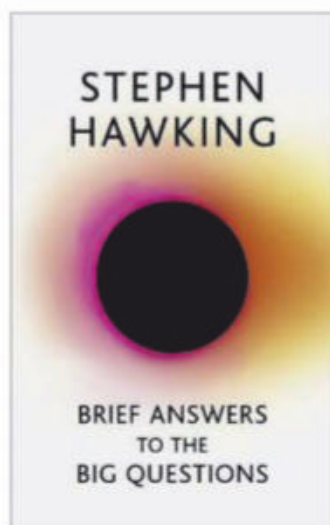
What are your observing highlights?

Since I stood in the shadow of the Moon during a total solar eclipse in 2017, I can safely place that third for the coolest thing I've ever seen. I've seen some amazing aurorae from both Northern Maine and Alaska, but most amazing was the 1998 Leonid meteor shower from Kuwait. The zenithal hourly rate approached near 1,000 meteors towards dawn, with brilliant fireballs lighting up the desert.

What are your favourite observing destinations?

Southern Arizona is a mecca for astronomy. I was also recently at the Nebraska Star Party and the sky was so dark that the Milky Way was actually casting a shadow. Some areas along the Los Alcornocales Natural Park in southern Spain are gloriously dark and easily accessible. But your 'observatory' is wherever you can get a good view of the sky; there's one deep-sky photo in the book of the Orion Nebula that was shot from a New York City fire escape!

David Dickinson is an Earth science teacher, freelance science writer and backyard astronomer who ponders the Universe as he travels the world with his wife



Brief Answers to the Big Questions

Stephen Hawking
John Murray
£14.99 • HB

“How did it all begin? Is there other

intelligent life in the Universe? Is time travel possible?” These are just a few examples of the big questions that Stephen Hawking discusses in his final book *Brief Answers to the Big Questions*. Each of the 10 questions forms a chapter that explores a difficult topic that all of us have no doubt wondered about in our lives. Hawking does not simply give us one-word answers to all those questions but walks us through his own thinking and divergences on each subject.

This book is really for everyone. The language is easy to follow and each chapter's length keeps you engaged. In places the book touches on some

complicated physics, but you will never feel lost. The only equation in the book is unsurprisingly Hawking's own, which I think we can all agree is fair!

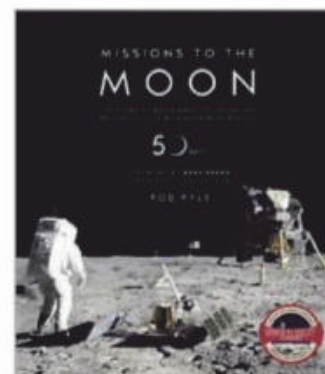
If you didn't get beyond the first few chapters of *A Brief History of Time*, this title will be a real treat in its clarity on the big questions. There are many inspiring parts of the book that will stay with you and will shape the way you think about these big questions in the future.

This is a truly wonderful little book that really does get you thinking and, most importantly, looking up at the stars. And on behalf of every curious girl and woman out there, thank you Professor Hawking for your encouraging words in the closing paragraphs.

★★★★★

Laura Nuttall is a Senior Lecturer in *Gravitational Waves at the Institute of Cosmology and Gravitation at the University of Portsmouth*

Missions to the Moon



Rod Pyle
Andre Deutsch
£25 • HB

With the upcoming 50th Anniversary of the Apollo 11

mission – the one that put humans on the Moon – we can expect a deluge of books this year about lunar space programmes. Finding a unique perspective on the subject will be essential for authors hoping you'll part with cash for their book rather than one of the others.

And Rod Pyle's latest book, a comprehensive anthology of NASA's lunar missions, is one of the more eye-catching. Told principally through stunning photography and original sources from the era, Pyle has indeed found his unique angle, with a foreword from Apollo Flight Director Gene Kranz and clever use of digital 'augmented' technology that delivers archive material – video, audio and 360° imagery – to the reader's smartphone. There are interesting documents to peruse including flight directors' reports, spacesuit designs and lunar rover schematics, but I felt that there was room for more. Nevertheless, the inclusion of this historically significant memorabilia draws the reader in, bringing the humanity of the space programme more to life.

While three of the 27 chapters are dedicated to the lunar programmes of Russia, China, ESA and others, this book is more of a celebration of the extraordinary feat of the Apollo programme.

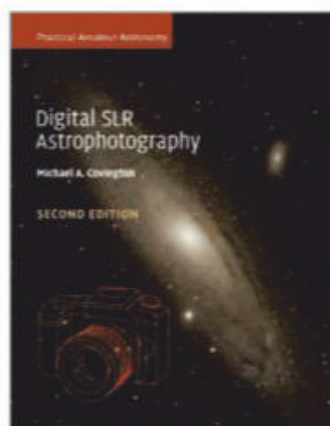
“Our work in space is unfinished,” says Kranz, “and my hope is that a new generation of explorers will once again find the leadership, the spirit and the courage to boldly go forward and complete what we started.”

To that end, *Missions to the Moon* is, “a meaningful step in that direction,” he boldly states. I'm not so sure, although the book is certainly a collector's piece for space enthusiasts of all ages.

★★★★★

Niamh Shaw is an engineer, lecturer and science communicator

Digital SLR Astrophotography



Michael A Covington
Cambridge University Press
£27.99 • PB

With the coming of age of cooled CMOS cameras

designed specifically for astrophotography, you could be forgiven for thinking that the days of DSLR astrophotography are numbered. But, if this book is anything to go by, that really isn't the case.

In the second edition of Covington's popular book we are treated to a very comprehensive overview of DSLR imaging, with topics covering the way the cameras work, how to get the best out of them using ordinary camera lenses, how to attach them to a telescope and how to process the captured images.

There is also useful information on telescope and mount types, polar alignment and obtaining accurate tracking as objects traverse the night sky.

Each section is complemented with some excellent explanatory diagrams and it was satisfying to note that the ray trace diagrams for various instruments were all accurate! There are copious high-quality photographs printed on good quality paper throughout the book although disappointingly, these are all greyscale.

The image processing section will be of particular interest to beginners as imaging is 50 per cent capture and 50 per cent processing, the latter being considered a 'dark art' when you start out. The topics in this section are sometimes a little condensed but work flows are discussed for no less than five different software packages: DeepSkyStacker, MaxIm DL, Nebulosity, Photoshop and PixInsight, each serving as a useful primer.

With an 'Advanced Topics' section at the end, there is something here for everyone interested in astrophotography.

★★★★★

Steve Richards is an astro imager and author of *Making Every Photon Count: A Beginner's Guide to Deep Sky Astrophotography*

Elizabeth Pearson rounds up the latest astronomical accessories

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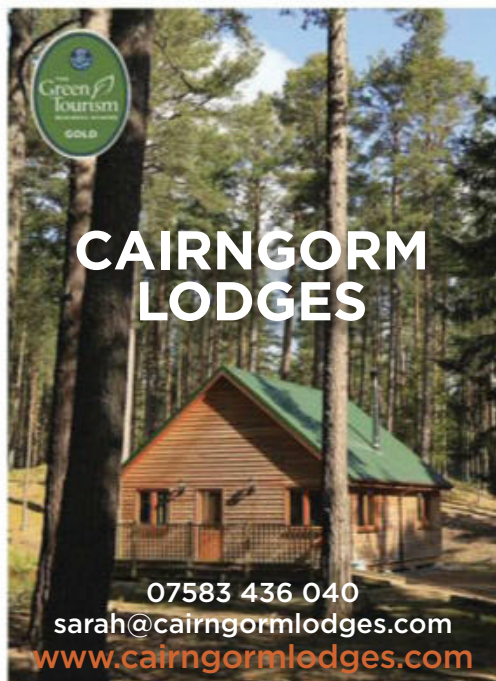


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WHAT I REALLY WANT TO KNOW IS...

What does the Moon tell us about the Universe?

Dr Benjamin McKinley is using radio interferometry and the Moon to peer back to a time when the first stars were born

The Moon has become an unlikely tool in our project to measure the average levels of hydrogen in the earliest days of the Universe.

About 370,000 years after the Big Bang, matter in the Universe had cooled down enough so that atoms could form, with protons and electrons combining to create neutral hydrogen. For the first time there were stable atoms floating in space, but there are no stars or galaxies at this point, so no light that you can look at. It's very hard to probe that time in the Universe – but the Moon is helping us do it.

Pretty much the whole early Universe was made up of hydrogen atoms and a little bit of helium. If you have hydrogen floating in space, every now and then it will randomly emit a photon with a wavelength of 21cm.

The ultimate aim of my project is to detect this 21cm radiation from neutral hydrogen at the time when the first stars and galaxies were forming; from this we can learn more about cosmology and the sources of the first radiation in the Universe.

As the Universe has expanded over time, this has expanded the photons as well. They get what's called 'redshifted' – stretched out so that by the time we observe them on Earth they are between 1m and 3m in wavelength. That's what our radio telescope, the Murchison Widefield Array (MWA) in Western Australia, detects.

Beyond the Moon

Our particular project is looking at the average neutral hydrogen signal across the entire sky at different frequencies. Other experiments trying to detect this average signal normally use a single antenna to give the total brightness of the signal in the sky. The MWA, though, is an interferometer with lots of small antennae – 128 tiles with 16 antennae each – joined together. It's kind of like having a telescope with lots of holes in it so we are missing



▲ With the Moon as a reference point of known brightness and shape, scientists can infer conditions in the early Universe from the area that's being occulted



Benjamin McKinley leads a team of astronomers in Australia at the Curtin University node of the International Centre for Radio Astronomy Research (ICRAR)

information – including this average signal. By putting the Moon in the field of view, it produces a known change in brightness, and by comparing these fluctuations we can infer what that average hydrogen brightness might be.

In theory, we are assuming we know about the Moon, and it's what's behind the Moon that we're measuring. We have to know how bright the Moon is and exactly what shape it is to do this.

When you measure the average brightness of the neutral hydrogen signal in the sky at different radio frequencies, that translates to different epochs in the Universe.

Each radio channel and frequency corresponds to a different time because of that redshift effect – as the Universe expands the 21cm photon gets stretched out.

If we look at how the strength of the redshifted 21cm signal changes with frequency as you go up and down in the radio channels, we can see how much radiation the early stars and galaxies were pumping out, how many there were and how they were clustered. There's a lot of information that we can extract.

We are probing the period between 200 million and one billion years after the Big Bang – the Epoch of Reionisation. That's the period when the first stars and galaxies started to knock electrons off neutral hydrogen atoms. Slowly these bubbles of ionised hydrogen form and the 21cm signal decreases in intensity. There's been a lot of theoretical work on how the neutral hydrogen signal might change at different frequencies. The idea is if we can measure this really accurately, we can compare it to the theoretical curves. Depending on where different turning points in that curve are, you can say when the first stars and galaxies started to heat the Universe, when reionisation started, when all the neutral hydrogen had gone and we were left with only ionised hydrogen.

At that point the Universe looks a lot like it does today. But that timeline is pretty unknown.

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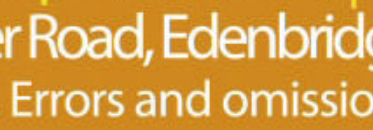
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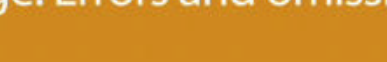
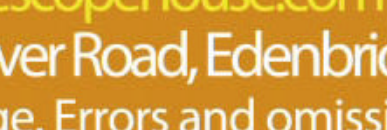


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THE SOUTHERN HEMISPHERE



With Glenn Dawes

February's Southern sky offers the chance of a binocular view of Mars sailing by Uranus

When to use this chart

1 Feb at 24:00 AEDT (13:00 UT)
15 Feb at 24:00 AEDT (13:00 UT)
28 Feb at 23:00 AEDT (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

FEBRUARY HIGHLIGHTS

Although just visible to the naked eye, Uranus can be an evasive target. This month, Mars flies past Uranus in the early evening, making a great marker. On 7–19 February the planets are within 4°, being closest on 13 February at only 1°. One of the main Southern Hemisphere meteor showers, the Alpha Centaurids, peaks on 8 February. Active from around 31 January to 20 February, numbers have been low in recent years, but they are known for producing brightly coloured fireballs.

STARS AND CONSTELLATIONS

Eta (η) Carinae is a remarkable star. Around 120 times more massive and five million times more luminous than the Sun, it has been known to be variable for centuries. But astronomers were astonished when a massive eruption in 1842 briefly made it the sky's second-brightest star and created the Homunculus Nebula. It belongs to an open cluster of massive stars called Trumpler 16, whose UV emissions power the glow of the Carina Nebula. It is currently mag. +4 to +5.

THE PLANETS

In the evening sky, Mercury is near maximum brilliance, but poorly visible deep in the twilight glare. Mars and Uranus need to be caught early, both setting around 22:00 AEDT (11:00 UT) midmonth. The remaining planetary action is in the

early hours. Jupiter rises just after midnight, easily outshining nearby star Antares. A little later sees the arrival of Venus and Saturn, best seen around an hour before sunrise. The planets pass closely on 19 February, separated by only 1.1°.

DEEP-SKY OBJECTS

Volans, the Flying Fish, is an obscure constellation in the far south between Carina and the Large Magellanic Cloud. Kappa (κ) Volantis (RA 8hr 20.0m, Dec. -71° 30") is an easy, wide triple star whose members form a nearly straight line. The main pair, Kappa¹ and Kappa², are blue-white and mag. +5.3 and +5.6 respectively. Kappa² is 1 arcminute northeast of Kappa¹, with the fainter Kappa³

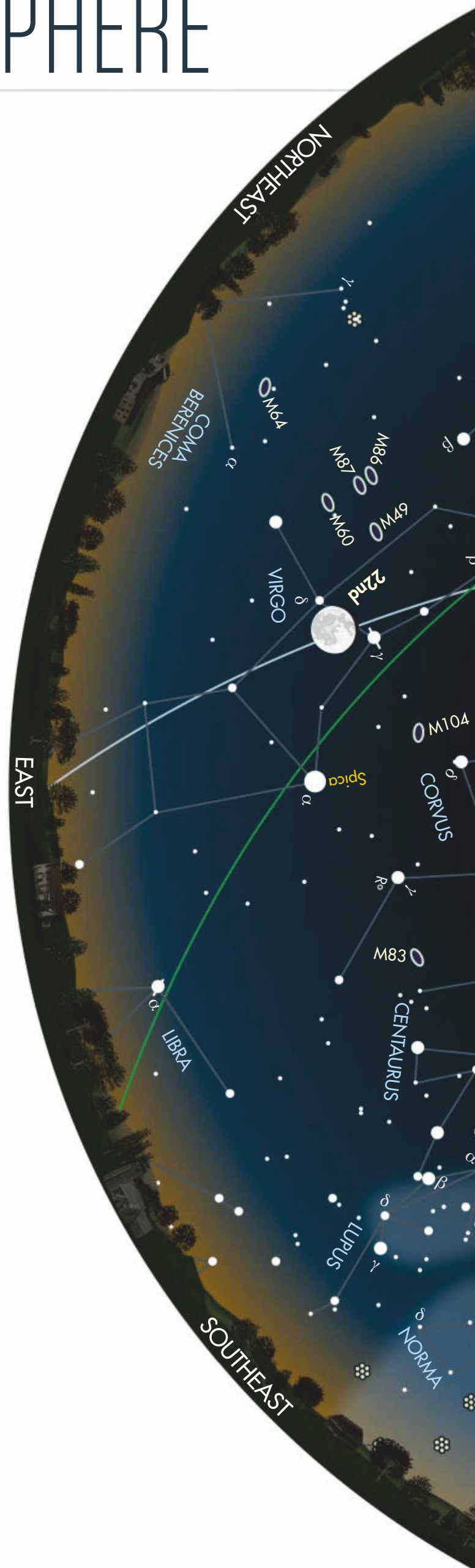
0.6 arcminutes further along in the same general direction.

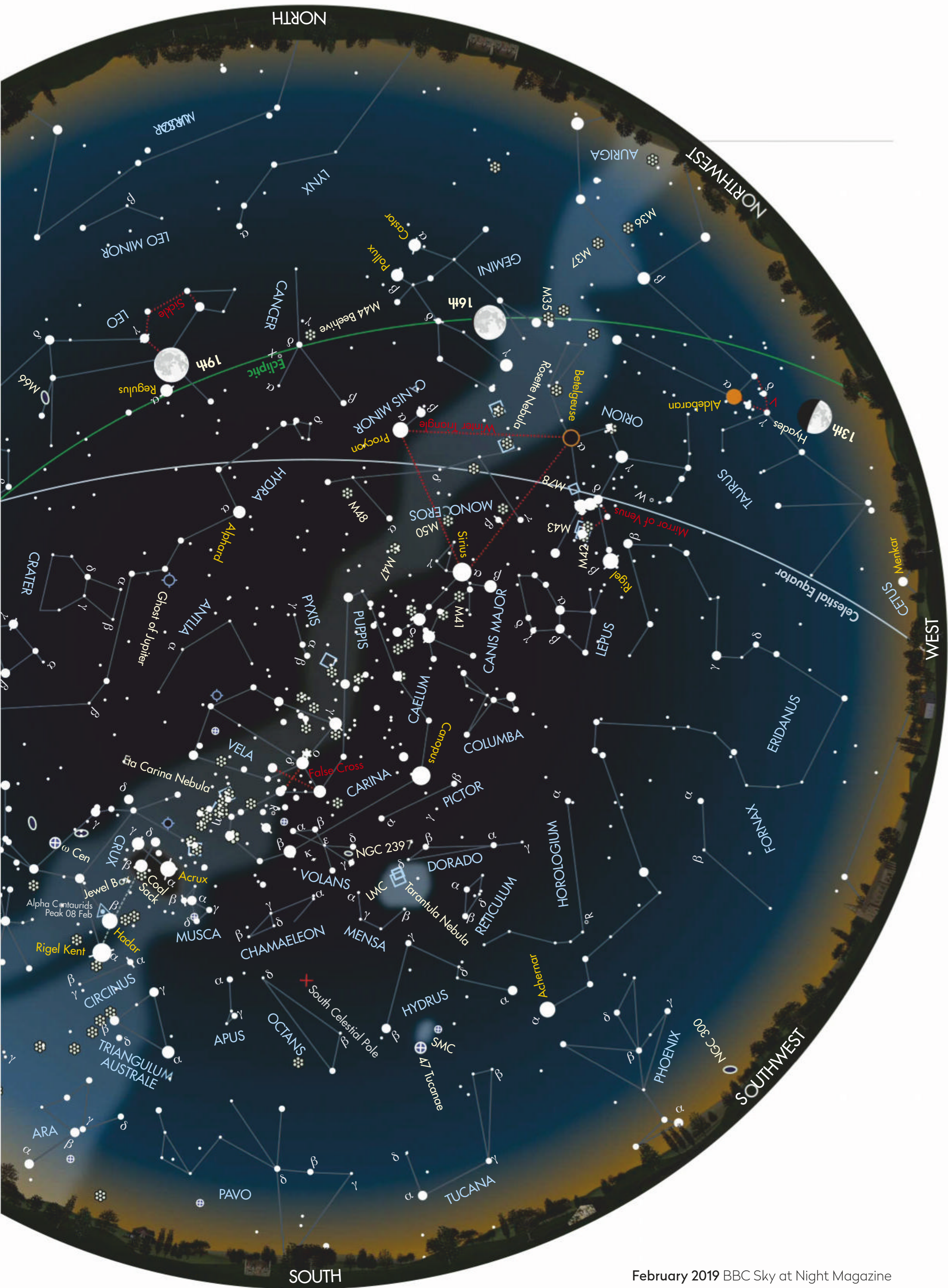
A more challenging object is the galaxy NGC 2397 (pictured, RA 7hr 21.3m, Dec. -69° 00"), a compact, mag. +11.8 spiral located 1° southwest of the mag. +4.0 star, Delta (δ) Volantis. It has an elongated (2.0'x0.5') reasonably bright halo, with a small but obvious slightly oval core.

Chart key

GALAXY	DIFFUSE NEBULOSITY	ASTEROID TRACK	STAR BRIGHTNESS: ● MAG. 0 & BRIGHTER ● MAG. +1 ● MAG. +2 ● MAG. +3 ● MAG. +4 & FAINTER
OPEN CLUSTER	DOUBLE STAR	METEOR RADIANT	
GLOBULAR CLUSTER	VARIABLE STAR	QUASAR	
PLANETARY NEBULA	COMET TRACK	PLANET	

CHART: PETE LAWRENCE





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